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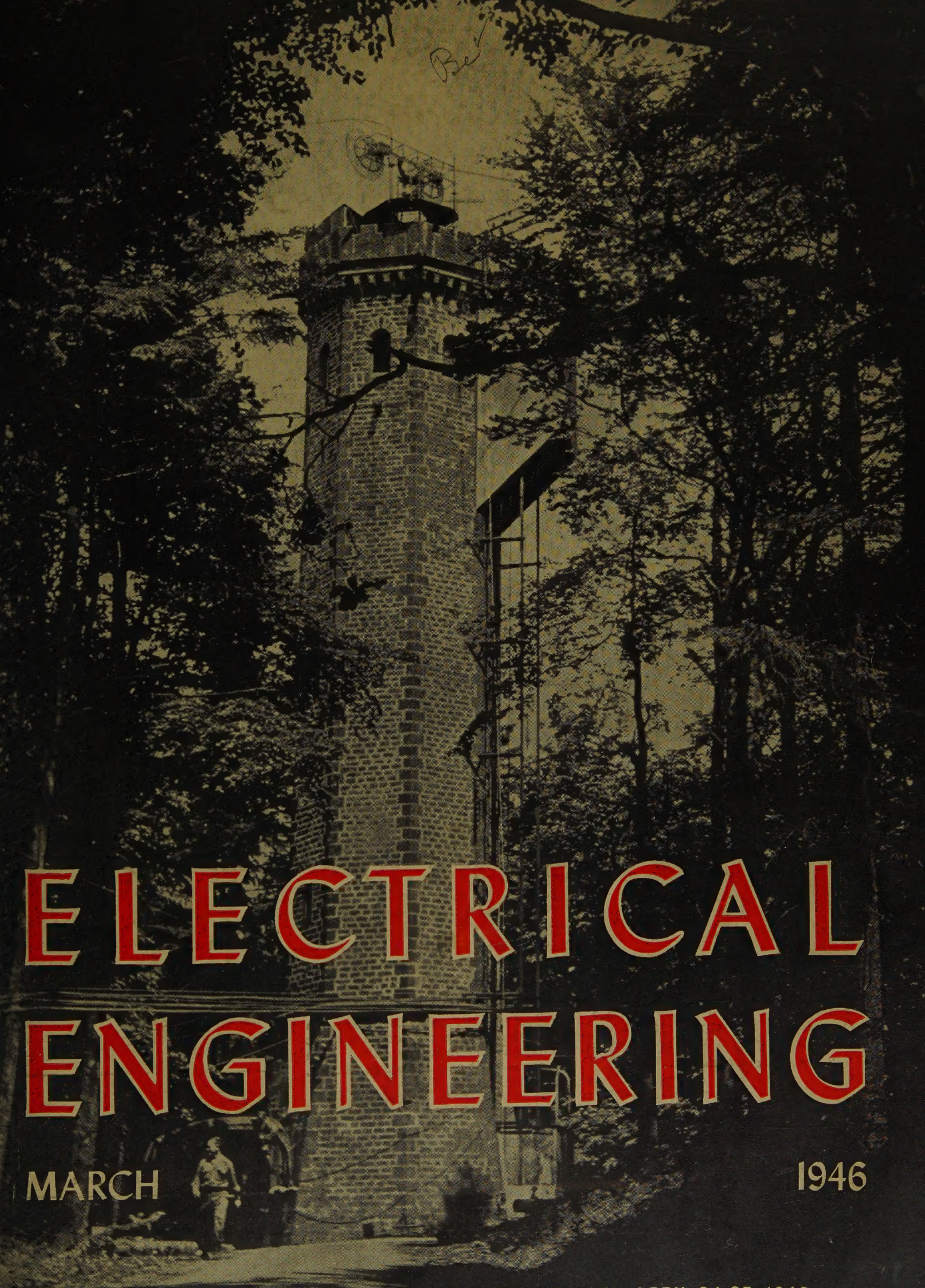
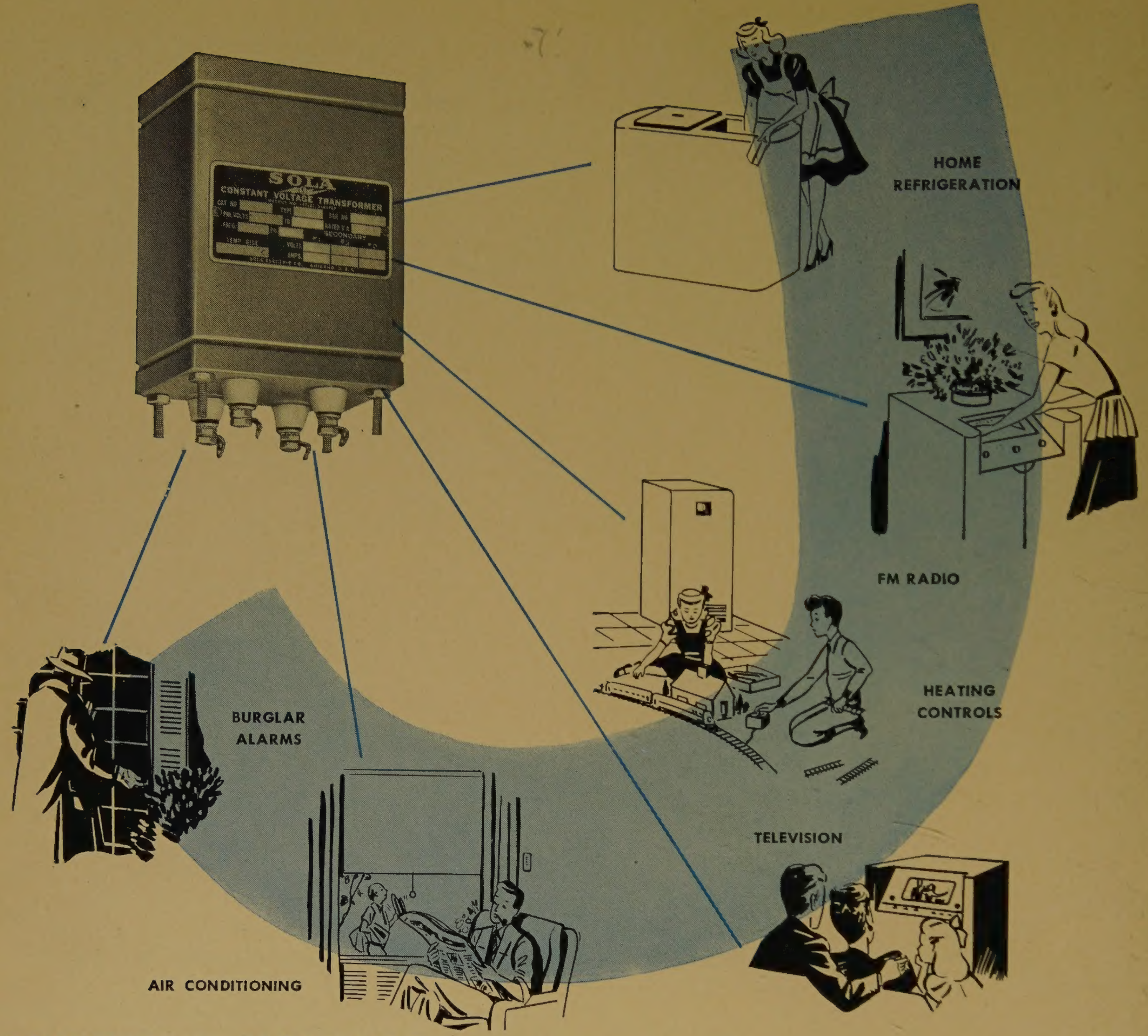


ELECTRICAL ENGINEERING

MARCH 1946

NORTH EASTERN DISTRICT MEETING, BUFFALO, N. Y., APRIL 24-25, 1946



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ELECTRICAL ENGINEERING

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1946

Cover: Terminal of microwave radio relay system at Heidelberg, Germany
Bell Laboratories photo

Communications: Implement to Peace ... Ray C. Wakefield ... 99
Centralized Power Generation ... Philip Sporn ... 105
Progress in Nuclear Physics
  I. "Nuclear Disintegrations" ... 108
  II. Review of Basic Concepts ... 110
  III. Chronology of Bomb Research ... 113
Statistical Methods in Quality Control—X ... AIEE Subcommittee ... 117
Miscellaneous Short Item:
  Testing Gauge, 119
Institute Activities ... 120
Of Current Interest ... 139

TRANSACTIONS SECTION

(Follows EE page 144; a preprint of pages 97–176 of the 1946 volume. Any discussion of these papers will appear in the June 1946 "Supplement to Electrical Engineering—Transactions Section" and in the 1946 volume.)

Arc Starting Characteristics of D-C Welders ... Joseph M. Tyrner ... 97
Stress Measurement ... Robert E. Kern, Sidney B. Williams ... 100
Linear Couplers ... E. L. Harder, E. H. Klemmer, R. E. Neidig ... 107
Long 60-Cycle Arcs in Air ... A. P. Strom ... 113
Industrial Application of Rototrol Regulators ... W. R. Harris ... 118
Thermal-Demand-Meter Testing Techniques ... E. E. Lynch, M. E. Douglass ... 124
Electric Drive for Calender Train ... K. W. John, G. W. Knapp, W. A. Mosteller ... 128
Crystal Channel Filter for Broad Band Carrier Systems ... E. S. Willis ... 134
Die Cast Rotor Testing by Test Stator Method ... P. H. Trickey ... 139
Series Capacitor Protective Device ... R. E. Marbury, J. B. Owens ... 142
B-H Curve Tracer for Magnetic-Recording Wire ... T. H. Long, G. D. McMullen ... 146
Automatic Oscillograph With a Memory ... A. M. Zarem ... 150
Capacitor Discharge Welding Transformers ... T. W. Dietz, G. M. Stein ... 154
Phonograph Reproducer Design ... W. S. Bachman ... 159
Testing of Hydroelectric Units ... G. D. Floyd, J. J. Traill ... 163
Dielectric Recovery by an A-C Arc in an Air Blast ... T. E. Browne, Jr. ... 169

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Statements and opinions given in articles and papers appearing in *Electrical Engineering* are the expressions of contributors, for which the Institute assumes no responsibility. ¶ Correspondence is invited on all controversial matters.

Published Monthly by the

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

Founded 1884

VOLUME 65
NUMBER 3

WILLIAM E. WICKENDEN, President
H. H. HENLINE, Secretary

PUBLICATION COMMITTEE: C. F. Wagner, *chairman*, M. S. Coover, H. H. Henline, B. M. Jones, John Mills, J. J. Orr, H. H. Race, G. A. Van Brunt

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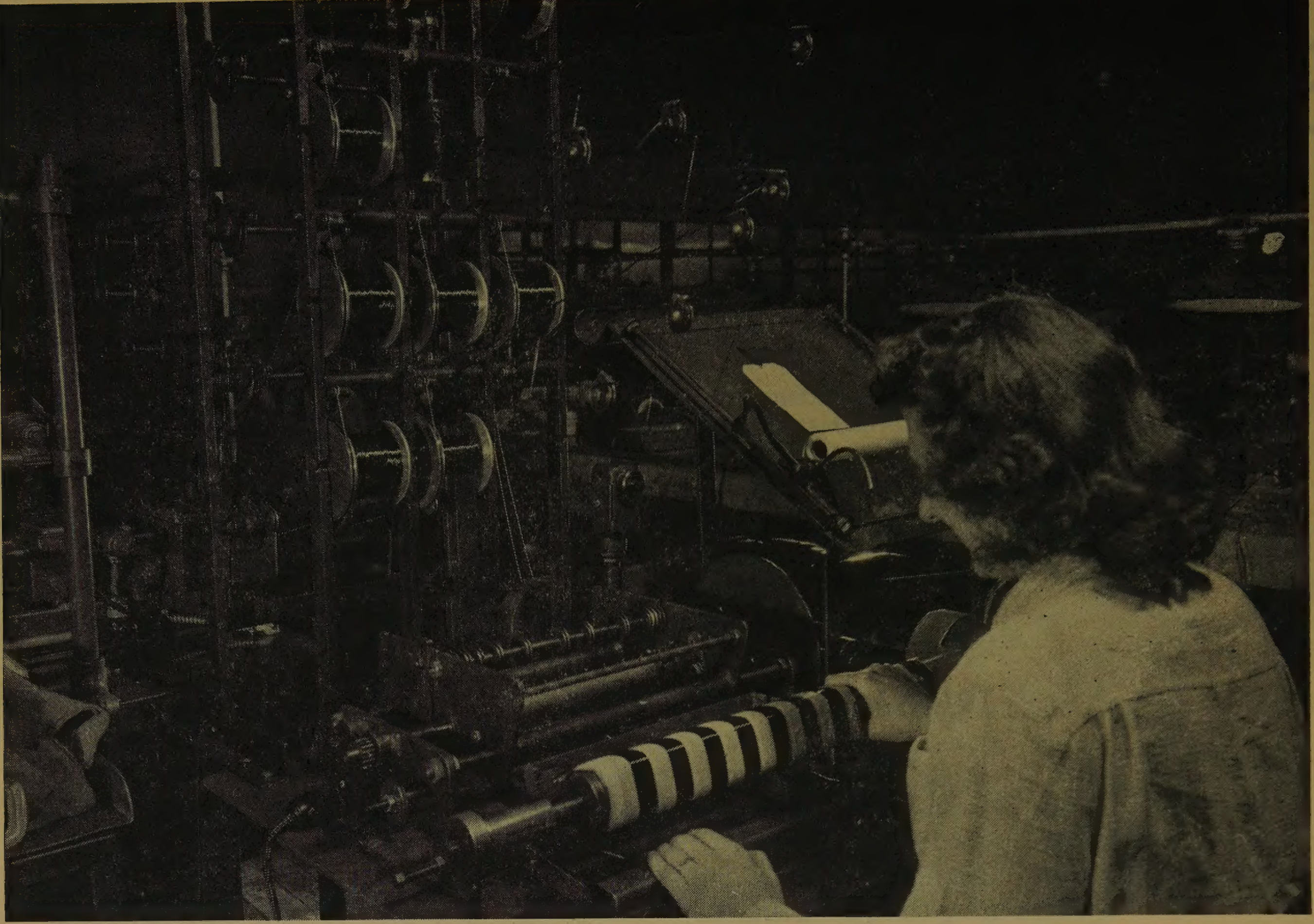

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NATURAL AND SYNTHETIC ENAMEL AND TEXTILE INSULATIONS

HIGHLIGHTS........

Winter Convention. With a verified total registration of 2,624 the 1946 winter convention set a new attendance record by a margin of more than 35 per cent. The reports given in this issue reflect the convention high lights, including the salient features of the several conferences and the principal actions taken at the various committee meetings. This was the first AIEE convention at which session attendance was strictly limited to persons wearing the convention-registration badge. Also, the $2.00 nonmember registration fee was required. The results of these control measures were highly successful, and well justified the extra effort put forth by committee personnel in policing the entrances to meeting rooms (*pages 122–3*).

District Meetings. Two District meetings are scheduled for the month of April: The South West District meeting at San Antonio, Texas, April 16–18; and the North Eastern District meeting at Buffalo, N. Y., April 24–26. Advance program details are given for the San Antonio meeting (*pages 120–1*). Program details for the Buffalo meeting are scheduled for publication in the April issue of *Electrical Engineering.*

Nuclear Research Reviewed. A tripartite staff report reflects the prophetic 1940 winter convention address of Dr. Enrico Fermi of Columbia University, presents a brief review of some of the basic concepts which underlay and were proved by concentrated wartime research, and presents a chronology of selected high lights of the wartime atomic bomb project. This is preliminary to the scheduled early publication of 1946 winter convention addresses concerning present understandings of the possibilities of the newly found nuclear energy (*pages 108–16*).

World-Wide Communications. Communications can play an important role in co-operation and mutual understanding between nations, the qualities which promote peace. Developments during World War II have solved or have pointed the way to the solution of most of the technical problems entailed by an international communication system. Will the obstacles provided by diplomacy and politics be overcome as easily (*pages 99–105*)?

Series Capacitor Protection. A series capacitor is protected best from overvoltage during fault by a gap having low arc drop with no tendency to cutoff. A new type of by-pass switch automatically by-passes the gap and series capacitor and removes the by-pass after the fault has cleared. The device is used in combination with a special design of graphite gap with self-centering arc characteristics (*Transactions pages 142–6*).

Stress Measurement. A large portion of current strength testing of finished products is accomplished by means of resistance measurements on fine-wire filaments bonded to the surface of the test element. To use such a gauge most effectively the tester should know the product designer's problem and some of his methods of gauge data analysis as well as be familiar with gauge installation, operation, and circuit theory (*Transactions pages 100–07*).

Linear Couplers. A new protective system employing linear couplers, or air-core mutual reactors, was installed for the protection of 114-kv busses at York and Middletown, Pa. The tests made on this pioneer installation are interpreted and the field of application is discussed (*Transactions pages 107–13*).

Meter Testing. With the increasing use of thermal meters testing methods more nearly resembling those of the mechanical type will be desired. Former techniques which were particularly applicable to thermal meters consumed a considerable amount of time but shorter testing methods can be devised (*Transactions pages 124–8*).

Quality Control. The quality of most electric equipment cannot be judged by the simple per-cent-defective method because of the many characteristics involved. In the current article of the statistical series a method of rating is considered which recognizes differences in the seriousness of defects, and makes use of a system of weighting them accordingly (*pages 117–19*).

News 120

South West District Meeting 120
Winter Convention 122
North Eastern District Meeting 122
Edison Medalist 124
Hoover Medalist 125
Engineers' Reading List 139
Future Meetings
  AIEE 130
  Other Societies 142
Personal Items 130
Membership 137
Letters to the Editor 142
New Books 144
Pamphlets 144

Co-ordinated Electric Drive. A co-ordinated electric drive has been developed which is more successful than a mechanical drive in such processes as the coating of fabrics with rubber. The new electric drive employs amplidyne as well as electronic control (*Transactions pages 128–34*).

Automatic Oscillograph. The persistence of fluorescence, a characteristic of cathode-ray tube screens, is utilized to obtain electrical memory on an instrument which can record automatically electrical conditions before, during, and after a transient. One example of its use is the recording of transients which may occur during the operation of a mercury-arc polyphase converter (*Transactions pages 150–4*).

Rototrol Regulators. The Rototrol is a simple and reliable regulator which is finding increasing application in industry. Its fundamental theory, application of circuits most commonly used, and operating results for typical installations are discussed (*Transactions pages 118–23*).

Testing of Hydroelectric Units. The application of the "AIEE Test Code for Synchronous Machines" to acceptance testing of hydraulic-type generators is analyzed. The methods of testing given in the code which can be used are outlined and reasons are given why other methods are difficult or unsuitable for this type of generator (*Transactions pages 163–9*).

Welding Transformers. A capacitor discharge by way of a welding transformer is used to supply a closely controlled energy to the welding spot. A number of equations are derived from an analysis of the circuit which allow explicit calculation of the transformer dimensions from the measured components of the impedance (*Transactions pages 154–9*).

Phonograph Reproducers. Of two new phonograph reproducers one is a variable resistance type with a polarized strain sensitive wire resistance generator element and the other is a variable reluctance or magnetic type. Both have low mechanical impedance at stylus tip and high suspension compliance (*Transactions pages 159–62*).

AIEE Nominees. Biographical sketches of the nominees for AIEE 1946–47 national offices are given in the Personals columns (*pages 130–3*).

Correction. The a-c–d-c instrument shown on page 80 of the February issue of *Electrical Engineering* is of the moving-iron type and not of the moving-magnet type as erroneously labelled.

ELECTRICAL ENGINEERING. Published monthly by the American Institute of Electrical Engineers; publication office 20th & Northampton Streets, Easton, Pa. Editorial and advertising offices, 33 West 39th Street, New York 18, N. Y. Subscription $12 per year plus extra postage charge to all countries to which the second-class postage rate does not apply; single copy $1.50. Entered as second-class matter at the Post Office, Easton, Pa., under the Act of Congress of March 3, 1879. Accepted for mailing at special postage rates provided for in Section 538, P. L. & R. Act of February 28, 1925. March 1946, Vol. 65, No. 3. Number of copies of this issue 30,350.

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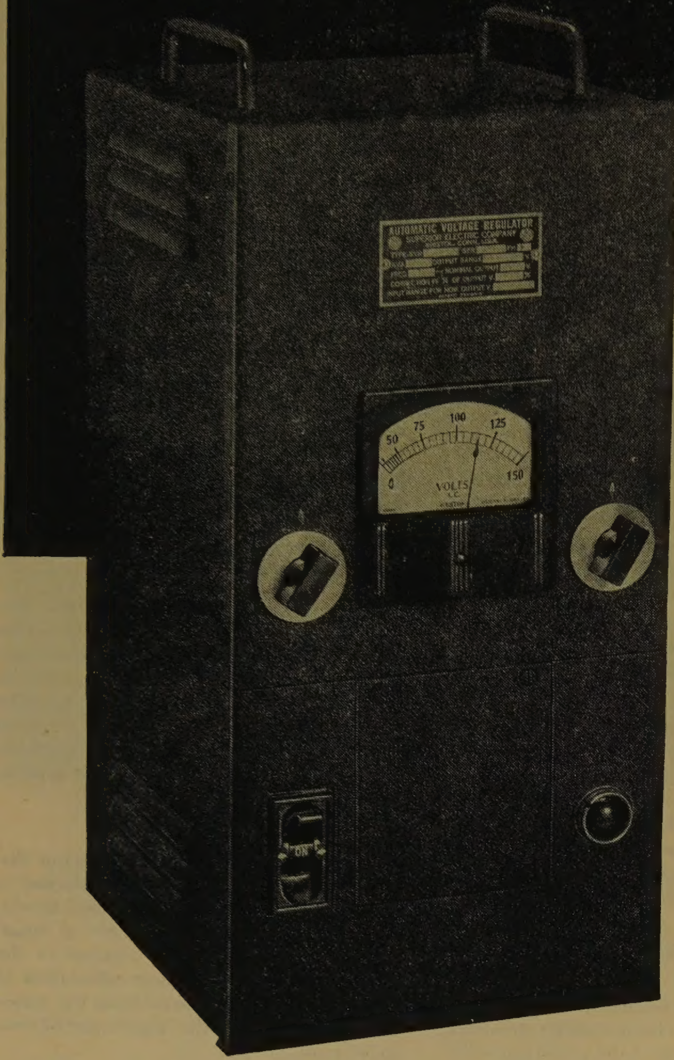

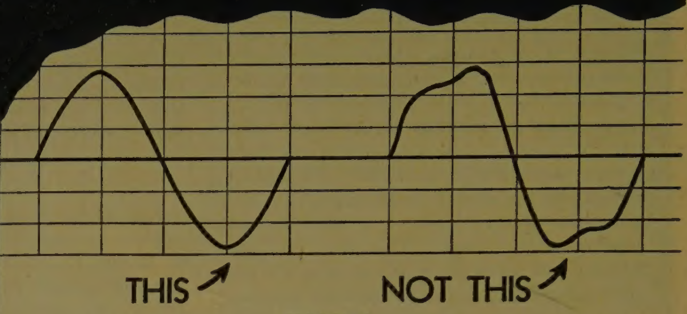

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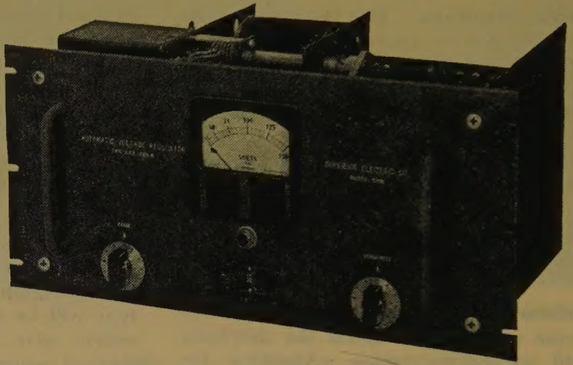

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Communications: Implement to Peace

RAY C. WAKEFIELD

During World War II the United States Army developed a system of world-wide communications unexcelled in scope, both technically and geographically. The author describes some of these improvements and suggests immediate steps to insure the development of a comparable commercial communications system in recognition of the great contribution that instantaneous communication can make to international relations.

IN MODERN TIMES the structure of any industry rests firmly upon its technical development. During the war, the technology of communications underwent revolutionary changes which necessarily affected and will affect further systems of communication, especially international communication.

The first of these developments was the opening up of the higher regions of the spectrum for practical utilization. Before the war, recognized communication services were limited mostly to frequencies under 300,000 kilocycles, although far higher frequencies were known, at least in theory, to be usable. As Federal Communications Commission Chairman Paul A. Porter expressed it in his testimony endorsing the proposed Federal agency for scientific research:

> "For many years, the human race has been like a fortunate young wastrel who inherits a vast estate, and then fails to use or even explore more than a portion of it."

That is no longer the case. As a result of wartime research, the upper limit of the usable radio spectrum has been raised to 30 million kilocycles (30,000 megacycles) which makes possible a tremendous expansion of radio services generally.

The so-called "beamed radio relay" is an example of the new services which can be established through the use of these ultrahigh frequency "microwaves." Five companies already have received experimental authorizations from the Federal Communications Commission to construct experimental radio relay beams. In general, their plans involve the erection of a series of low-powered radio stations at intervals of 20 or 30 miles along such routes as New York–Boston, New York–Washington, or even New York–San Francisco. Each of these stations is equipped with highly directional antennas, of a type growing out of wartime radar research, so that it can beam a bundle of radio circuits from point to point without wasting the power of the transmitter in directions other than the direction toward which the circuits are beamed. At each station, a directional receiving antenna picks up the beamed signal, amplifies it, and beams it on to the next relay point making it possible for a large number of telephone, telegraph, teletypewriter, facsimile, and television circuits to be handled simultaneously.

The newly opened regions of the spectrum have short-range characteristics; and while it is possible to overcome this short-range limitation in domestic communications by erecting chains of such stations at intervals across the country, it is not possible to utilize microwaves in this way for transoceanic communication. The region of the spectrum usable for international communications, accordingly, remains limited for the present to frequencies below 30 megacycles but wartime research has brought a number of developments which make possible a much more intensive use of these bands.

One such development is "frequency shift keying" in radiotelegraphy, in which the carrier amplitude remains constant while the frequency is shifted from one value for the "mark" signal to another value for the "space" signal. The two frequencies employed may differ by only a few hundred cycles. This system tends to overcome selective fading as well as certain amounts of interference. Should the signal on either frequency fade or be interfered with, the signal on the remaining frequency can be utilized. Extensive use of this system has been made by the Armed Forces and several commercial companies.

A means of making many signals travel over a channel which formerly carried only one is the awkwardly named "single sideband multitone multiplex transmission" which permits the simultaneous transmission of numerous messages on each side of the carrier, or the transmission of a telephone conversation on one side and several telegraph messages simultaneously on the other. This technique has contributed substantially toward the saving of valuable radio spectrum space.

Still another development is the adaptation of "time division multiplex telegraphy" to radio circuits. Time division multiplex has been in use on wire circuits for a number of years and with modern improvements it has become practicable on radio circuits. This type of multiplex operation, when combined with the use of printers, permits the handling of upward of eight telegraph channels simultaneously by means of a single radio transmitter. This system has contributed more toward the sav-

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Essential substance of an address presented before the AIEE San Francisco (Calif.) Section, December 28, 1945.

Ray C. Wakefield is Commissioner, Federal Communications Commission, Washington, D. C.

ing of frequency space than the multitone channeling system, but requires more complicated terminal office equipment than the latter.

Not only have the methods of keying radio transmitters been improved, but keying speeds have been doubled over certain circuits. Whereas 400 words per minute was considered top speed before the war, circuits handling 800 words are now in daily operation. The foregoing techniques are not, of course, necessarily cumulative but rather give alternate methods of improving reliability, speed of service, or otherwise saving frequencies.

Another development, "pulse time modulation," makes use of the fact that the human ear hears a series of rapidly produced sounds as one continuous sound and so, instead of sending out a continuous radio signal, sends out a series of separate pulse-like signals at very frequent intervals. Nevertheless, the transmitter is used for only a fraction of the time to transmit a particular message, and thus the time between pulses is left available for many other messages, similarly pulse modulated. Twenty-four messages have been transmitted simultaneously in this way over a single transmitter.

A somewhat more speculative communication development is "stratovision," a means whereby airplanes, flying in circles at a height of about six miles above the surface of the earth, can be used as relay points. An estimated eight airplanes would be necessary for coast-to-coast relay transmission. Whether stratovision actually will develop such relay systems depends, of course, on relative economic considerations as compared with the relay beam and coaxial cable. One of the most interesting features of this stratovision operation is that the same airplanes which are used as relays also can be used to broadcast to the areas beneath them. One of the problems of frequency modulation and television with their relatively short distances of transmission has been how to reach the rural listeners in the wide open spaces. This broadcasting from airplanes may be an answer to that problem.

Along with these developments, improvements have been made in the facsimile transmission of pictures, printed and written matter, both by wire and radio, and the remarkable development of portable and mobile equipment, including the widely publicized walkie-talkies and handy-talkies.

Technicalities aside, what will these developments mean in terms of ordinary human life? The answer to that question cannot be stated as yet, but it is safe to predict that the tremendous improvements in communications techniques which lie immediately ahead will have at least as great an effect as previous communication developments. Just as the pony express brought California into the commonwealth of states and the transcontinental railroad mail service linked the United States still more firmly as a nation, and just as the coming of the telegraph and the long distance telephone profoundly altered national patterns of thought and action, so it well may be that better communications between countries will strengthen and stimulate mutual understanding and make of us one people of one world.

Technologically, the United States can achieve a world-wide communications system. What are some of the problems, human and otherwise, to be met? Have there been deficiencies in prewar communications operations? If so, how can they be remedied? Perhaps the best way to answer these questions is to compare briefly the status of privately owned communication facilities and the "wartime" world-wide communication system of the Armed Forces.

Privately operated international communication assets, at present, consist of three major communication types. The oldest form of international communication is the cable. The British, who were the great builders of cables during the 19th century, retain a dominant position in the cable picture with control over approximately 58 per cent of the world's cables as compared with the United States which controls, roughly, 32 per cent. The remaining 10 per cent is divided among France, Denmark, and before the war, Italy and Germany. British cables serve some 46 major overseas points while the United States cables link 28 important communication terminals.

Challenging the primacy of the cables is the radiotelegraph, in which field the United States has taken an unchallenged lead with direct linkage to some 70 foreign points of communication as compared with British circuits to approximately 40 overseas points.

Telegraph messages destined for foreign points of communications which are not linked with the United States by direct communication facilities are transmitted to a connecting foreign carrier who then retransmits the message to its point of destination. For example, no direct facilities are available between the United States and Capetown, South Africa, or Rabat, French Morocco, and messages from New York to either place first must be transmitted to London or Paris for retransmission by way of British or French facilities to Capetown or Rabat. The difficulties arising from such roundabout methods of communication are obvious. Details of the operation are duplicated, and there are frequently long hours of delay at the connecting point bottleneck, as such messages become submerged in all of the telegraph traffic of the respective foreign terminal.

A third major means of international communication is the radiotelephone which now provides direct communication between the United States and 39 foreign points of communication which interconnect with the domestic telephone systems of many countries. Eventually it should be possible by means of radiotelephone and landlines to link any two telephones in any two countries of the world.

These three media of communication—the cable, the radiotelegraph, and the radiotelephone—constituted the

Figure 1. Terminal station on a United States Army circuit between Wiesbaden and Augsburg, Germany

communications facilities with which the United States entered World War II. It quickly became apparent, however, that many points of crucial wartime importance could not be reached over these privately owned facilities, and that the combined capacity of such private installations was far from adequate to handle the tremendous volume of international war messages. Accordingly, great systems of communications were established by the Army and Navy under the outstanding leadership of General Frank E. Stoner, Chief of the Army Communications Service of the Signal Corps, and Admiral Joseph R. Redman, Director of Naval Communications. The importance of these military systems of international communications can be indicated by the fact that the estimated investment in the Army and the Navy communications systems totals at least 250 million dollars as compared with private depreciated investments of approximately 54 million dollars in all United States owned international cable, radiotelegraph, and radiotelephone facilities.

The United States Army system is perhaps the only communications system which is world-wide in a literal sense. It radiates from the War Department in Washington, covers the United States by leased landline circuits, and spreads out by radio to every foreign spot where American troops have been stationed. It utilizes the "radio relays" at five strategic locations along the approximate region of the equator. By means of interconnection with teletypewriter devices, it has made the operation of these relay stations semiautomatic, capable of forwarding messages without the delay incident to manual operation. The automatic relay station in receiving the incoming message on a machine perforates a tape which is used to key the transmitter for forwarding the message. Tape perforators and automatic relay stations also have made possible the holding of teletype conferences between parties separated by one-half the circumference of the globe and over circuits which heretofore have been too long and unreliable for this type of service.

Privately owned international radiotelegraph companies maintain direct circuits to such countries as Russia, Australia, New Zealand, India, and China but these circuits cannot guarantee continuous service. To some points they may be usable only a few hours a day because of operating difficulties resulting from the long transmission paths and the proximity of such paths to the north polar regions where they are attenuated severely. The Army's five automatic relay stations located at Algiers, Asmara, New Delhi, Manila, and Honolulu approach the ideal equatorial belt which has been proposed by communication engineers. Its establishment recognized that radio communication in a north–south direction is, generally, more reliable than in an east–west direction, particularly in the northern and southern latitudes and that transmission near the equator is far more reliable than parallel transmission considerably north or south of it. A message to Moscow, for example, instead of being sent by the direct path from San Francisco, and thus being exposed to the absorption encountered in the auroral regions, could be transmitted by wireline to Washington, then by radio to Algiers from where it is relayed automatically to Moscow. This routing avoids the auroral zone and each portion of the route covers a comparatively short distance thus affording communication 24 hours a day.

Expensive and elaborate equipment at both ends of a long direct circuit is required even though little traffic moves over the circuit. The nonavailability of such equipment at low volume traffic points, in many instances, has precluded the establishment of direct circuits between the United States and particular foreign points. The Army relay stations have been used advantageously as a relay point for traffic to and from many of such low volume centers, thus making possible the use of comparatively inexpensive facilities at the foreign end.

As a result of this and other advantages, the international military communications of the United States have indicated how good a world-wide communications system can be. Some military circuits can handle messages at a rate of 800 words per minute as compared with cable speeds of 40 to 60 words per minute, and private radiotelegraph speeds averaging 60 words per minute. The Army and Navy networks have handled as many as 50 million words per day, compared with a capacity of roughly $12^1/_2$ million words per day for all the United States private carriers combined. By use of the Army's semiautomatic relay system, it takes a message but $3^1/_2$ minutes to circle the globe.

If the United States is to have the best possible postwar system of international communications, rather than return to the standards of the prewar period, it seems that certain definite steps must be taken in the immediate future. The following is a brief outline of these steps; not as a matured plan for postwar international communications, but as a bare minimum of what must be done.

First. Strategically located radio relay stations must be established.

In considering this matter, one thing must be borne in mind; namely, that private carriers, and the same would be true of a government in peacetime, will not have the same opportunity that the Army had in setting up its world-wide communications system to place radio transmitters, relay stations, or receivers at almost any place in allied or friendly countries where they were needed or could be used best. The very general practice among nations, to which we rigidly adhere, is that no one but a national citizen, or a corporation of any sovereign nation, or the government itself, can operate communication transmitters upon its territory. This means that despite the fact that semiautomatic relays are not used for original transmissions, diplomatic problems are involved in placing relay stations on foreign territory, and that unlike the Army system which also operated the foreign end of each of its circuits, United States communication carriers must communicate with the foreign agency at the foreign end of each circuit.

The Algiers, Asmara, and New Delhi relay points used by the superlative Army system were made available to the United States for the duration of the war and six months thereafter. Accordingly, their operation cannot be continued in the future under existing arrangements. However, other strategic relay points may be available for American operation. For example, three United States carriers plan to establish radio relays at the International Settlement of Tangier which will serve the same function that the Army–Algiers installation served during the war. Arrangements for one or two additional relay points to close the gap from Tangier to the Philippines and Hawaii might make it possible to continue the world-wide Army relay belt.

Second. Immediate policies are necessary with respect to the disposal of surplus military communications equipment which will insure that the equipment remains continuously useful. Certainly the disposition of the Army relay stations should await immediate diplomatic exploration. There are also other types of communication equipment at present scattered throughout the world. Under the Surplus Property Act, such surplus military communications property cannot be imported into the United States for commercial purposes but either must be junked or used abroad although it is of the utmost importance to world-wide communications that this equipment be kept in working order as part of a postwar communications system.

International communication is, of necessity, a two-way system and a rapid, efficient, and world-wide system of communications depends upon the equipment, practices, and co-operation of the foreign agencies. Inferior equipment at a foreign point can delay and impede communication. The failure of the United States international carriers to establish a more efficient world-wide system has been attributed in no small part to the nonavailability of equipment at the foreign end, or to the inferior equipment in the hands of the foreign carriers with which they communicate. It well may be that one of the most important steps that can be taken to improve international communications is to make any surplus Army and Navy equipment available on the most reasonable terms and conditions possible to foreign agencies.

Finally, and of the utmost importance, it is the author's opinion that the ideal international communications system cannot be achieved without merging into one company all privately owned international telegraph and cable carriers, with the exception of Press Wireless, Inc.

The development of a privately owned international communications system in the United States has been on the basis of bitter competitive struggles among private commercial groups. There are eight international telegraph companies organized for the purpose of handling all classes of traffic. In addition, Press Wireless has built up a world-wide system to major points, originally for the purpose of handling press traffic exclusively, but during the war it was authorized to handle government messages and in some instances commercial traffic. R.C.A. Communications, Inc., and Mackay Radio and Telegraph Company compete in the radiotelegraph field on a world-wide basis. The Commercial Cable Company and Western Union Telegraph Company compete in the Atlantic cable field but link the United States directly to only a few major points of communications in Europe. Commercial Pacific Cable Company, one-fourth American owned, and Globe Wireless operate directly to a relatively few points in the Pacific. Tropical Radio Telegraph Company serves the Caribbean area and Central America and the northern part of South America. The All America Cable and Radio Company and Western Union operate cables to Latin America. Several of these companies (Commercial Cables, All America, Mackay, and the American fourth of Commercial Pacific) are under the common control of the International Telephone and Telegraph Company.

Most of those who work in the international communications field, both in government and in industry, agree that the competition of the United States carriers has forced a wasteful duplication of investment, costs of service, and facilities; that it has required the expenditure of effort and resources of the carriers in their attempts to divert business at major points of communications from one to the other; and that such competitive operations do not lend themselves readily to the routing and distribution of international traffic in the manner most likely to assure prompt and efficient service. Of perhaps even more importance is the fact that competitive carriers make less than full use of the scarce and limited radio frequencies. Despite the rapid improvement in radio art, the supply of radio channels still is limited, and maintaining two circuits along a route where the traffic could be handled by one is clearly wasteful.

The frequency saving argument is an important one. The radio frequencies best suited for long distance communications are so scarce that there is virtual agreement among interested United States Government agencies that no such frequencies will be used for domestic communication where wirelines are or can be made available.

What to do with existing international cables constitutes one of the major postwar communication problems. Radio has forged ahead of cables as a method of communication and has proved itself to be a far less expensive, as well as a more versatile, method of communication. United States radiotelegraph carriers, as stated, have established direct circuits with 70 foreign points as compared with 28 served by direct cable connections; yet the investment, after depreciation, in radiotelegraph is only 10 million dollars as compared with 39 million dollars for cables.

Prior to May 1945, cable and radiotelegraph rates were geared largely to cable costs rather than low cost radio operations. Rates were predicated upon the much higher cable investment costs and distance factors, despite the fact that distance has a very small effect upon the cost of transmitting an international radiotelegraph message. Thus, there arose a pattern of nonuniform rates. Until May 1945 the full rate to London was 20 cents per word, with a press rate of 3 cents a word. Other rates ranged from 29 cents to Finland, to 33 cents to Bulgaria, with a press rate from 4 cents to 9 cents a word, depending upon the United States carriers' route over which the traffic was sent. The full rate to China was 88 cents per word and the press rate varied according to the agreement reached by the United States carrier with the Chinese National Government, ranging from $12^1/_2$ cents to 16 cents per word.

Since May 1945, for the first time in the history of United States communications, a 20-cent uniform rate, more nearly geared to radio costs, and disregarding distance factors, has been applied to outbound communications from the United States to Europe, Latin America, the Philippine Islands, China, and Asiatic Russia. Press rates to many points of communication also have been reduced. But rates which apply to traffic between the United States and Africa, parts of the Asiatic area, to British Empire points of communication, and to French Empire points of communication remain at their prewar high cable-geared level. For example, the present full rate to Algiers is 30 cents a word; to French Indo-China, 81 cents; to Cairo, 42 cents; and to Australia, 60 cents.

This problem was discussed at a recent conference between United States and British Government and communication representatives in Bermuda and, as a result, it was agreed that, not later than April 1, 1946, rates between any point in the United States and any place in the British Empire will be not more than 30 cents per full rate word and the press rate will be reduced to not more than $6^1/_2$ cents per word.

Some advocates of merger believe that consolidation should be limited to permitting radio carriers to merge into one company and cable operators in a second company, and that these two companies should fight it out to see which shall survive. The argument advanced in favor of this is that a merged company, embracing both radio and cable, may be weighted with the present depreciated investment in cables of 39 million dollars and so would be held back in its greatest use of radio by its desire to protect its cable investment. Obviously, on an investment cost basis, cables cannot compete effectively with radio, except possibly on the heavy traffic routes.

Against this are the facts that neither the military authorities nor the State Department ever have taken the position officially that cables may not still be required for privacy and secrecy, that it may be desirable to retain cables between points of *high traffic density* for the purpose of saving frequencies, and that some engineers believe that cable operation still may be as economical as radio operation along heavy traffic lanes, such as between New York and London. It is also a fact, however, that many Army and Navy communications authorities have stated that radio operations can be as secret as cables.

The British are much more inclined than we in the United States to attempt to protect the full existing investment in cables. However, that they are not unanimous in this view is shown by the following letter written by Sir Ernest Fiske, formerly a director of the Amalgamated Wireless of Australia, which appeared in the London *Times* on October 16, 1945.

> "May I open this letter by stating that I have no personal interest in the economics of any newspaper or press association. I have, however, a keen and long-established interest in the utility and efficiency of British oversea communication services, in which field I have been directly occupied both in pioneering and in operating for many years.
>
> "I have read the published copy of a letter from the president of

the Empire Press Union to the Prime Minister's adviser on public relations concerning the important question of telegraph charges for press messages between the separate parts of the British Commonwealth and Empire, and I am surprised to learn that there should be, in these days, any suggestion of increasing the charges for such communications. I can only imagine one reason to justify any increase in these charges—namely, that the high costs of an older submarine cable service are to be met out of the revenues of more up-to-date beam wireless services. Without such a handicap beam wireless, with its modern improvements, should be capable of linking all British territories for high-speed telegraph communication with great efficiency and at low cost.

"The question whether submarine cables are essential for defense purposes is one to be determined by the expert defense advisers to the Governments, but an alternative question whether a modern system of commercial communication ought to be shackled with a cost required largely for security is one of great concern to the press, to the commerce, and to the social welfare of British people in all parts of the world. No reasonable person would suggest that revenues earned by the British Merchant Marine should be applied to the support of the Navy, nor that the traffic charges of commercial air services should be handicapped by the cost of maintaining a defensive Air Force.

"British territories are located round and about the world in a manner which permits effective use to be made of modern science and engineering to provide efficient radio telegraph and radio telephone services with far greater carrying capacity and much lower operating costs than are possible with long submarine cables. Fuller use of these modern developments, which are largely British in their origin, would involve relatively low capital outlay and would provide such efficient means of communication and such high traffic capacity as to permit of much lower charges being made for all classes of traffic than exist today. In such circumstances there should be no suggestion of increasing the press rate, but rather investigation as to the possibility of substantial reduction for all classes of traffic. The urgent necessity for developing the vast resources of the British nations and colonies all over the world is now widely appreciated, and I submit that a major contributing factor in that development should be the utmost use of scientific and engineering knowledge in the field of cheap and efficient oversea communication."

Sir Ernest's assertion that modern radiotelegraph developments are "largely British in their origin" is subject for debate but his philosophy of international telegraph operations and rate making is agreeable. If cables are to be maintained solely for security purposes, it would seem that the cost should be borne by the taxpayer rather than the rate payer.

It is evident that the same issue of high cable investments versus low radiotelegraph costs, and the same need for cheap world-wide telecommunications, must be faced by the United States. It is the author's opinion that any sensible United States postwar communications program must recognize the increasing obsolescence of existing cable facilities, and that the merged company should take over the existing cables at a price which would be commensurate with their *value* in a merged worldwide communications system. All existing cables may be used as a part of a general communications system so long as the expense of replacement and major repairs does not appear formidable. It is essential, however, that a merged company not be saddled with an investment in cables higher than their worth in a technically advancing industry and that adequate provision be made for amortization following the merger.

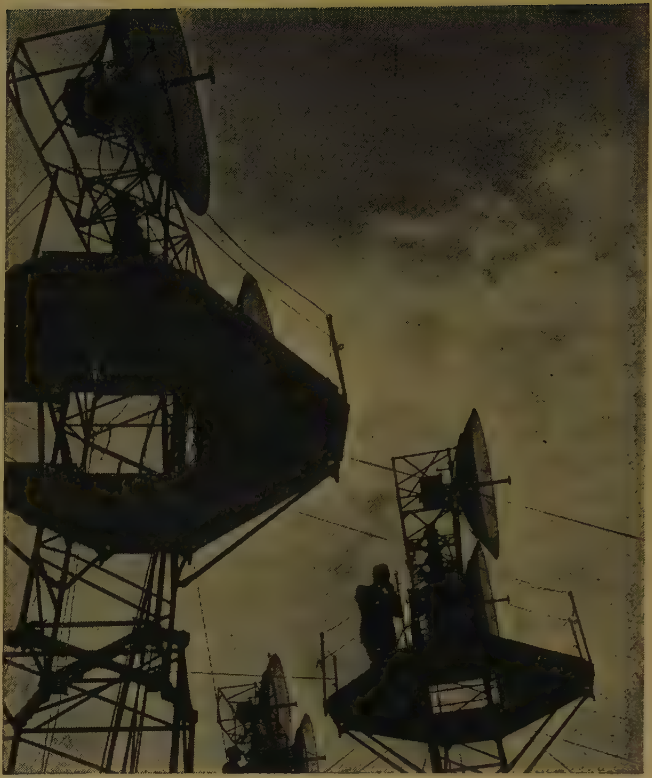

Figure 2. Upper parts of antenna towers of AN/TRC-6 system

There seems to be considerable merit to arguments for the continued existence of Press Wireless, Inc., as an independent press communications agency, provided adequate frequencies can be found, and provided its emergency wartime commercial and governmental traffic services are abandoned. It is not contemplated that the merged carriers shall be prohibited from transmitting press messages, but that the exclusive press carrier should concentrate its operations upon the special needs and requirements of the press for high priority in transmission of press material at low rates throughout the world.

Eventually the merged carrier may supply the press with service so good at rates so low that a separate press carrier will not be necessary but until then the public and the news agencies of the United States are entitled to the continued independent operation of Press Wireless as a carrier of press messages exclusively.

An objection to merger of any kind is the argument that it would abolish competition and that competition is a means whereby benefits are conferred upon the public through better or more efficient goods or services at lower costs. This argument loses much of its weight with reference to public utility operations. Moreover, a merger involving only radiotelegraph and cable carriers retains very real competition. Even if cable and radiotelegraph companies were merged into a single concern, with Press Wireless exempt from the merger, competition nevertheless would remain among three media of communications; the airmail, the merged radiotelegraph and cable carriers, and radiotelephone. Inferior service or high rates on one type of operation would shift traffic to another. The essence of competition would be retained, while the waste resulting from duplication of identical circuits between identical points would be eliminated. In addition, both the American Telephone and Telegraph Company and Press Wireless have been responsible for many technological communication advances. Exclusion of these companies from the merger would continue to serve as a stimulus to the merged carrier to use the most modern equipment and would provide a yardstick as to whether it was doing so.

These various communication developments have a deeper significance however. At the technological level there seems to be no cause for concern. During the war scientists and engineers outdistanced their prewar achievements and undoubtedly this type of progress will continue unabated. More difficult is the problem of organizing these media of communication upon sound economic and social foundations, so that they will be freely available for the use of the people of the world. And more difficult still will be the ultimate task of assuring that the organized communication facilities of the world will be used in the interests of peace and unity.

No matter what machinery of world organization is evolved, permanent peace cannot come without a more perfect understanding among the peoples and governments of the world, and a world-wide communication system such as has been described can contribute mightily to that understanding. This much of a contribution to world peace is almost certain. Any further contribution depends upon the use that is made of the system.

Centralized Power Generation

PHILIP SPORN
FELLOW AIEE

Central station power, Thomas Edison's outstanding accomplishment, thus far has met the test of economic practicality and commercial success, but its relative economy and dependability in an ever-expanding industrial system presents one of the main problems of the postwar era. Additional problems are posed by the possibilities of atomic energy, although just how great a role it can play in the power generation field probably will not be determined for some time.

THE YEAR 1945 will be notable in history for many things: the year in which the greatest and most widespread war in the history of human civilization came to an end; the year in which the United Nations Organization, with the successful functioning of which so much of the future of civilization is bound up, was launched; and, perhaps above all, the year in which the practicability of atomic fission was established and with it the principle of equivalence of mass and energy demonstrated. That demonstration and the work behind it will affect many phases of existence. But it now begins to look as if, excluding the purely military and the world political fields, it will have its greatest peacetime influence on activities devoted to the generation and transmission of power. It may not be too far amiss to say that whether many of the complex world political problems are solved before the world is subjected to another war, the mere beginning of which would constitute the greatest human tragedy since the beginning of time, will depend in large measure on whether the development of atomic or nuclear energy is diverted from the military field of destruction to the peacetime channels of human betterment. One of the most important of these channels, it appears now, may be the field of centralized power generation.

In that field of power generation Thomas Edison reached his crowning achievement. His genius was responsible for a multitude of inventions that have had a profound influence on modern life: the telephone transmitter, the phonograph, and the kinetoscope. Each of these in turn not only came forth and very soon found broad application, but each continued to spread its influence and to serve as a nucleus about which others could build and develop new ideas, applications, and industries. But none of these, important as they were, had the transcendent effect on life and civilization that Edison's incandescent lamp and his system of genera-

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Essential substance of the Edison Medalist's address before a general session of the AIEE winter convention, New York, N. Y., January 23, 1946.

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tion and distribution exercised. True, Edison's initial work did not include transmission; that was to come later with the introduction of alternating current, the development of which, as a matter of fact, Edison unsuccessfully opposed.

But even if Edison was to nod later, that does not detract from the amazing creative genius displayed by him in bringing forth a complete system of central station electrical supply involving the generation of electrical energy on a large scale, its distribution throughout extended areas, and its division into small units radiating in every direction from the point of supply where they could be converted into light, each unit independent of every other and each under the control of the user. Despite the fact that he had no well-established theory to support him, and no precedent to guide him, Edison in the three years between 1879 and 1882, invented, developed, and worked out the principles and details of a comprehensive system of generation, control, distribution, and measurement and did it with a completeness and sureness that is amazing, and that has withstood the test of time.

All this is known perhaps to most of those who have devoted their major efforts to improvements in the field of power supply. What is not known so well is the amount of effort that Edison invested in developing the protective features of his system—fuse blocks, fuses, cutouts, switches, auxiliary busses, special circuit breakers—all of these ideas and inventions literally poured from his brain in a dazzling stream. Truly, Edison was mindful of dependability as an indispensable characteristic of a successful central station system.

Perhaps even less known is Edison's preoccupation with the efficiency of his original system. He had a clear concept that his system not only must meet the requirement of practicability, but also the rigid test of practicality. It had to be an economical system to meet the tough commercial competition of gas. When, in the process of developing his successful dynamo, Edison was confronted with the then generally accepted criterion of sound design, namely, that in order to operate under the best conditions generators must be arranged in such a manner that their internal resistance shall be equal to that of the external circuit, he refuted the idea.

"It is ridiculous," he said. "Do you think I want to lose 50 per cent of the power I apply? Why electric lighting never could be worked commercially on that basis. . . . . I am going to try to make my internal resistance as low as I possibly can."[1] And he did. He was thoroughly alive to the need of having his system economical.

Those who have come after Edison have not followed blindly in his footsteps, but rather have been inspired by his genius and example to continue to explore, invent, and develop new apparatus, devices, and practices to meet the new conditions. As the central station industry grew, there came with that growth new problems brought about by expanding the service area to remote regions and the scope of its use in new applications, undreamed of in Edison's time. Edison's original system, which centered about the Pearl Street station, covered perhaps a single square mile. The coming of a-c transmission extended the limits of this area so that today single areas operating as a co-ordinated unit of 100,000 square miles are not only practicable, but can meet the hard test of economic practicality and commercial success. This has meant that the small community of 2,000 is able to obtain today a supply of electric power of almost unlimited quantity, and of a continuity equal to the highest metropolitan standards.

Alfred Korzybski in his book on man, "Manhood of Humanity," has pointed out that what he considers the true and basic differentiation between the three classes of life, vegetable, animal, and human, is this. The vegetable class is essentially a chemistry-binding group. It combines chemical elements for its existence. That is, it is limited by, and depends for existence entirely on, the chemistry of its immediate surroundings. Animals, on the other hand, are space-binders. They can roam over extensive distances. A lack of food in a particular location need have no adverse effects on individuals or species. Finally, man is differentiated from the other two groups by his time-binding ability. In addition to the chemical-binding and space-binding powers each generation of man is capable of obtaining for itself the results of all ideas, work, and developments of all generations of mankind that have preceded it and, from that base, build and add its share to the substance of human progress.

This philosophic concept is one of the most sapient ideas about man developed in our time. It well could be pondered upon and used as a guiding light by our social scientists, legislators, and statesmen. It is a pertinent fact that, although man since the first dawn of civilization has been a time-binder, his space-binding abilities were not developed fully until the advent of the steam engine which made possible the locomotive and the steamship; the discovery of the principle of electromagnetic induction which produced the telegraph and the telephone; the invention of the internal combustion engine which brought about the automobile and the airplane; and the development of electrical transmission of power. These four, and most definitely the last of them, have made it possible for man to free himself from the fetters of fixed location and have enabled him to carry on almost any activity wherever he so wishes. It is that liberation from the natural source of economical power, whether the stream or the mouth of the coal mine, or from the large center of industrial activity, that has made possible the spreading out of industry to the smaller cities, towns, and villages. This, in turn, has brought with it improvement in the social and economic status of large sections of the population. It is probable that this trend will continue to an even greater extent in the future than it has been effective in the past. Some have gone so far as to express the thought that it has doomed the further growth of large cities. This does not seem likely. But that it has introduced a balancing or restraining force on the unchecked expansion of large population centers, with its attendant ills, cannot be disputed. This, perhaps, constitutes the major achievement of the central station power art as exemplified in the modern integrated power system serving an extended area or region. But again it cannot be pointed out too strongly that the achievement would have been of no practical significance if it had not been accompanied by two most important characteristics; economy and dependability.

The maintenance of present standards of economy in the generation of electric energy, and then, from there, the advancing of these standards, is going to present a number of problems in the near future even independently of the problem presented by the potentialities of atomic power. The war not only witnessed an unprecedented industrial expansion in the United States, but showed clearly that the curve of that expansion is almost coincident with the curve of expansion of electric energy use. Unquestionably, the former would have been impossible without the latter.

The war also clearly brought into focus a changed viewpoint on fuel resources of the United States, a realization of the importance to the country's future and welfare of the use of its natural gas, petroleum, and higher grade coal resources as chemical compounds, and the assignment of the simple fuel function to the lower qualities of solid fuels. That, in many cases, of necessity will call for greater utilization of transmission if the economic factors are to be kept in balance, and particularly if they are to be improved under the new conditions. Because of that, and because in many cases the economical solution of the transmission problem attendant upon the handling of larger blocks of power calls for voltages higher than any attempted commercially heretofore, a major investigation and research program is being initiated. It will consider those elements of the extra-high voltage transmission problem which are now in the twilight zone of knowledge, but which need to be brought into a fully lighted area if the same reliability, coupled with the same economy, that has been obtained in lower transmission voltages is to continue.

Generation of electric energy, and particularly large scale generation, may be on the threshold of a period that will bring about more profound changes than any hitherto conceived. There has been a great deal of irresponsible talk about atomic energy in the last few months, a good deal of it of the "pie in the sky" variety. On the other hand, not enough people realize the significance of what happened in the New Mexico desert on July 16, 1945, when the validity of the Einstein equation postulating the equivalence of mass and energy was proved dramatically.

True, so far fissionable material has not been used to produce a regulated flow of superheated steam. It is likewise true that a very special boiler will be needed, and no such boiler has been built and probably has not been designed. Nevertheless, the fact that one pound of presently known fissionable materials can release 39×10^9 Btu of heat energy, the equivalent of that available from 1,500 to 2,000 tons of coal, cannot be avoided or neglected. Such elements present an engineering challenge that cannot remain unanswered. Nor is the fact that an atomic energy boiler has not been built up until now a sufficient obstacle. Undoubtedly one can be built. Unquestionably, too, the design of such a boiler will present major problems in heat transfer, in high temperature properties of alloys, and in protection for personnel against harmful radiations. These, however, do not appear to be insurmountable obstacles.

The real problem is one of economics. No one knows, for example, the cost of building such a boiler, nor the cost of operating it, and there is no definite knowledge as to the cost of fissionable materials that can be used in it after it is built. Thus no proper appraisal can be made as to whether such a boiler will bring about more or less economical generation than is possible today through modern steam boilers, and further developments of them, using conventional fuels. It very well may be that, to effect the necessary economy in an atomic power plant, the size of generating units will become far larger than anything previously used in the power field. It is obvious that here again the transmission problem will play an important role. But if atomic power can be developed on an economical and dependable basis, and only one potential plan largely utilizing proved steam equipment has been cited, then it most certainly will find abundant application. If that development should come about it will present but another demonstration of the amazing vitality of Edison's achievement, central station power.

There is no evidence that atomic power forthwith will revolutionize all electric energy supply in the United States, or in any other country having an abundance of economical coal resources. It may, and perhaps will, affect profoundly the generation aspects in some localities. But it will take time, longer than most people realize. The engineering and economic problems are numerous and in peacetime their solution necessarily will take a longer time than is acceptable in wartime. While the challenge that atomic energy presents cannot go unheeded, the extent to which the problems attendant upon its application to the electric power field will be solved completely and the speed with which they are solved will be determined, as they should, by its potential contribution to economical and dependable generation of power.

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Progress in Nuclear Research

A review of selected historical highlights of the efforts which culminated in the development of the atomic bomb and its challenge for the future.

BECAUSE its concepts and predictions have been borne out by the results of stimulated wartime research, and because its lucid description of cause and effect of nuclear fission is as good now as a refresher as it was in 1940 as a challenge, the 1940 winter convention address of Doctor Enrico Fermi, of Columbia University and winner of the 1938 Nobel Prize in physics, is here republished.

I. "Nuclear Disintegrations"

Republished from *Electrical Engineering*, February 1940

MUCH OF THE INFORMATION available at present on the structure of atomic nuclei has been gathered by a successful application of the technique of the so-called nuclear bombardments. This technique, initiated about 20 years ago by Lord Rutherford, consists in hurling against the nucleus a projectile (originally this was one of the alpha particles spontaneously emitted by radioactive substances) and in observing the changes in the nuclear structure produced by the impact. In the last years this technique has received new impetus due, on one hand, to the development of artificial sources of high-energy projectiles (high-voltage apparatuses and cyclotrons) and, on the other hand, to the discovery of the neutron.

Several hundreds of different artificial nuclear disintegrations have now been investigated. Their study has led to the development of the so-called nuclear chemistry in which, instead of changes of aggregations of atoms to form different molecules, as in chemistry, changes in the aggregation of neutrons and protons to form different nuclei are observed. This nuclear chemistry obeys rather simple rules, and the different types of nuclear reactions can be summarized as in the following paragraphs.

Nuclei have been bombarded so far mostly with the following types of projectiles: alpha particles, protons, deuterons, and neutrons. Whenever one of these particles strikes the nucleus it is incorporated into the nuclear structure, and another particle may be emitted which belongs to one of the same four types. In a few instances nuclear reactions have been produced by hard gamma rays or by high-energy electrons. We have further to add the many cases of radioactivity, both natural and artificial, in which an unstable nucleus spontaneously emits an alpha particle, or an electron (negative or positive). The residual nucleus that remains after the reaction is always different from the one before the impact. In general, however, the changes in atomic weight, or atomic number, are not very large. Indeed, the greatest changes in atomic number occur when an alpha particle is either absorbed or emitted in the process. Since the electric charge of the alpha particle is of two units, this produces a displacement in the atomic number of two places only.

In many cases in which a chemical identification of the reaction products of nuclear bombardment has been possible, it has been found consistently that the reaction products are either isotopes of the original element bombarded, or they differ from it in atomic number by only a few units. There was, therefore, a great sensation among nuclear physicists last year when Hahn and Strassman announced that by bombardment of uranium (atomic number 92) with neutrons, they had found definite evidence of the formation of some radioactive isotopes of barium (atomic number 56). Such a change by 36 units in the atomic number had never been considered possible before; subsequent investigation has shown that it corresponds to a nuclear reaction of an entirely new kind, in which the uranium nucleus splits into two fragments of comparable size.

This discovery of Hahn and Strassman has opened a very interesting new field of investigation. It is well known that all the heaviest elements of the periodic system are to some extent unstable, as is shown by their natural radioactivity. The physical reason for this instability is the electrostatic repulsion between the positively charged constituents of the nucleus. These repulsions are approximately proportional to the square of the nuclear charge and, therefore, increase considerably with increasing atomic number. Instability sets in when the electrostatic destructive forces overcome what we may call the cohesive forces of the nucleus.

The theory of nuclear forces is not yet developed so far as to enable us to calculate exactly at what value of atomic number instability sets in. Probably, however, this limit is not far beyond 92, the atomic number of uranium. The discovery of Hahn and Strassman shows, indeed, that in the case of uranium the relatively unimportant perturbation of the nuclear structure due to the capture of a neutron is already sometimes sufficient for breaking into pieces the nucleus, giving rise to the so-called fission process.

A pictorial image of the process has been suggested by Bohr, who compared this process with what happens when a liquid drop divides into two smaller droplets as a consequence of a very strong oscillation in which it changes from the original spherical form into an elongated shape. In the case of uranium, however, as soon as the two fragments are separated and the cohesive forces cease to attract them, the strong repulsion due to both fragments being positively charged, pushes them apart, impressing on them a relatively enormous kinetic energy. In fact, the amount of energy released in the fission process is approximately ten times greater than any amount of energy released in atomic disintegrations, it being of the order of 200 million electron volts. (An electron volt is defined as the amount of energy gained by an electron in passing from a point of low potential to a point one volt higher in potential.) Although the discovery of this process is only one year old, a great many investigations have been carried out in laboratories all over the world, so that a general description of the main features of the phenomenon is now possible, in which, however, many important details are still missing.

The fission process can be produced by bombardment with fast neutrons having energy above one million electron volts, and by slow neutrons, having energy corresponding to thermal agitation equivalent to a small fraction of an electron volt. Neutrons of intermediate energy are rather inefficient as agents for producing fission. It has been pointed out, especially by Bohr, that this fact might possibly be interpreted on the assumption that the fast-neutron and the slow-neutron process are due to two different isotopes of uranium. Probably the fast-neutron process is due to isotope 238, which represents more than 99 per cent of natural uranium, whereas the slow-neutron process might be attributed to a much rarer isotope of weight 235, which is known to be present in an amount somewhat less than 1 per cent and is the parent substance of the actinium radioactive family. No direct experimental information on this point, which is of considerable importance both from the theoretical and the practical point of view, is at present available.

Each fragment into which uranium splits in the fission process weighs approximately one-half of the original nucleus. Apparently, however, the fission does not always occur in exactly the same way, and there are certain limits between which the weight of the fragments can vary. Since each fragment gives rise to several artificially radioactive nuclei, it is clear that the fission process will produce a large variety of new radioactive elements. An extensive chemical investigation of these elements has been carried out in several laboratories and has already led to the identification of more than 20 such elements, but the list is probably still far from being complete.

When uranium undergoes fission some neutrons are emitted. It has not been decided so far whether these neutrons are emitted in the very act of fission, or a very short time after the process. The two fragments into which uranium splits get away with a very high internal excitation. The excitation energy might be so large as to produce the spontaneous emission of neutrons from the two fragments. The largest part of this emission of neutrons certainly occurs within an exceedingly short time after the fission; the emission of a small number of neutrons, however, lasts for some seconds after the fission process. This delayed emission of neutrons is probably a secondary process of some beta disintegration.

The emission of neutrons is not only an interesting feature of the phenomenon, but might perhaps be of far-reaching importance, as it opens at least one possibility of exploiting the fission of uranium for the production of nuclear reactions on a large scale.

Let us assume for a moment that in every fission process two neutrons are emitted (actually experiment shows that probably the average number of neutrons emitted is somewhat larger, between two and three). If this were so every neutron that enters the uranium nucleus and produces fission would give rise to two neutrons with the net gain of one. If we assume that these two neutrons again produce each one a fission we get at the end four neutrons from the original one. Any one of these four neutrons might again produce a fission, multiplying the number of neutrons once more by two, and so forth, until the number of neutrons might in principle be multiplied by an arbitrarily large factor, thus giving rise to a self-perpetuating nuclear reaction—the so-called chain reaction. In order that the chain reaction might occur, it is obviously necessary not only to have more than one neutron produced for every neutron that is absorbed in the process of fission, but also to be able to utilize for producing new fissions a large fraction of the neutrons produced; otherwise the loss might be larger than the gain.

Assuming, as before, that two neutrons are produced in every fission, it is evident that for the chain reaction to take place more than one-half of the neutrons produced must be used in new fission processes. There is now, on one hand, some loss of neutrons that diffuse outside of the reacting mass before they have a chance to react. This loss can be made, at least in principle, arbitrarily small, by increasing the amount of the reacting material. On the other hand, some of the neutrons are lost for the reaction because they are absorbed by uranium itself in a second process, which does not lead to fission but to the formation of a heavy radioactive isotope of uranium. Some absorption is finally due to those substances that must be present in order to slow down the neutrons, so as to increase their aptitude to react with uranium. Whether these absorptions are, or are not, sufficiently large to prevent the chain reaction, cannot be answered at present. The experiments require the use of very large amounts of both uranium and "slowing-down" materials and are, therefore, very expensive. The problem seems to me, however, worth the effort that its solution will cost. There is indeed a chance that research on these lines might open entirely new technical opportunities, whose range at present only can be guessed. The large release of energy by the reaction, whose development, by the way, could be controlled easily by simple mechanical devices, is indeed probably only one and very likely not the most important aspect of the problem. Far more important might eventually prove the production of radioactive materials and of neutrons in practically unlimited amounts, for medical, biological, and physical investigations. In conclusion, although there is only a chance of success, the stake appears large enough to justify some gambling.

II. Review of Basic Concepts

THE EXTENT to which the foregoing 1940 concepts have been vindicated or exceeded is now a matter of history in the record of the now famous "Manhattan Project" which culminated in the successful development of the so-called atomic bomb. In addition to military implications attention now is turning to the potential industrial uses of nuclear energy. This seems to be an appropriate time, therefore, to review the basic concepts as now understood, especially the more rudimentary ones which usually are taken for granted in a specific technical treatise.

Prior to 1919, no one had succeeded in disrupting the stability of ordinary nuclei or affecting the disintegration rates of those that were radioactive. In that year, Rutherford discovered that high-energy alpha particles could cause change in the nucleus of an ordinary element; specifically, a few atoms of nitrogen were changed into a few atoms of oxygen by bombardment with alpha particles. The process involved may be described as a helium nucleus of mass number 4 (an alpha particle) striking a nitrogen nucleus of mass number 14, producing an oxygen nucleus of mass number 17 and a hydrogen nucleus of mass number 1, the latter known as the proton and of special importance because it has the smallest mass of any nucleus. Continuation of similar experiments led to the discovery in 1940 that when the very energetic alpha particles from polonium fell on such light elements as beryllium, boron, or lithium, "an unusually penetrating radiation" was produced. This radiation was confused at first with gamma rays, but by 1932 was established as the all-important "neutron," an uncharged particle of about the same mass as the proton. Another major discovery was made in 1932: the "deuteron," a nucleus of "heavy" hydrogen (mass 2) which, although not one of the fundamental particles, does play an important role in certain processes for producing nuclear disintegration. Also, "positrons," particles of the same mass as the electron, and of equal but positive instead of negative charge, were discovered to be emitted from nuclei that were artificially radioactive.

Artificial radioactivity was discovered—or accomplished—in 1934. Boron, magnesium, and aluminum, after bombardment by alpha particles, were found to remain radioactive for some time. This result stimulated similar experiments all over the world. In particular, Enrico Fermi of Columbia University reasoned that neutrons, because of their lack of charge, should be effective in penetrating nuclei, especially those of high atomic number such as uranium which strongly repel the charged protons and alpha particles. He was able to confirm his prediction almost immediately, finding that the nucleus of the bombarded atom captured the neutron and thus became an unstable nucleus which then achieved stability by emitting an electron. Thus, the final stable nucleus was one unit higher in mass number and one unit higher in atomic number than the initial target nucleus.

Innumerable experiments since 1934 have led to the production of radioactive isotopes of nearly every element in the periodic table. Altogether, some 500 or more unstable nuclear species have been observed, and in most cases their atomic numbers and mass numbers have been identified. Some revert to stability by the emission of electrons, some by the emission of positrons, some by what is known as K-electron capture, and three by emission of alpha particles. Not only did these artifically radioactive elements play an important role throughout the atomic bomb project, but their future value in medical and other research hardly can be overestimated.

BASIC CONCEPTS

The Conservation of Mass and Energy. The first of the two principles that have been cornerstones of modern science is the 18th century enunciation that *matter* can be neither created nor destroyed, but only altered in form. The second is the 19th century enunciation that *energy* can neither be created nor destroyed, but only altered in form. The first led to the principle known as the law of the conservation of matter; the second is known as the law of the conservation of energy. Up to 1940 these were unaltered and separate. Now, it is known that they are but two phases of a single principle, for it has been discovered that sometimes matter may be converted into energy and energy into matter. Specifically, such a conversion is observed in the phenomenon of nuclear fission of uranium, a process in which atomic nuclei split into fragments with the resulting release of an enormous amount of energy. The development and military use of that energy was the objective of the wartime nuclear research which began in 1940.

The Equivalence of Mass and Energy. The conclusion that the inertial mass of a moving body increases as its speed increases appeared early in the evolution of the theory of relativity. This implied an equivalence between an increase in energy of motion (kinetic energy) of a body and an increase in its mass. To most practical physicists and engineers, this appeared to be but an interesting mathematical fiction of no particular importance. Even Einstein hardly could have foreseen present applications when, as early as 1905, he stated that mass and energy were equivalent, and suggested that proof might be found through the study of radioactive substances. His conclusion that the amount of energy E equivalent to a mass m was given by the equation $E=mc^2$, where c is the velocity of light, assumes startling proportions when stated in actual numbers in related units. If E is expressed in ergs and m in grams, c must be expressed in the centimeter equivalent of 186,000 miles per second or about one billion feet per second. Thus, it can be shown that a single kilogram (2.2 pounds) of matter if entirely converted into energy would give 25 billion kilowatt-hours of energy! This approximates the total energy generated by the entire United States electric power industry (as of 1939) during a 2-month period at full production. This is a fantastic figure as compared with the 8.5 kilowatt-hours of heat energy—or the 1.58 kilowatt-hours of electric energy—generated from the combustion of an equal amount of coal in the average United States steam-electric generating plant of 1939.

The extreme size of this conversion factor was interesting in several respects. First, it explained why the equivalence of mass and energy never was observed in ordinary chemical combustion. Second, it made clear that no appreciable quantities of matter were being converted into energy in any known terrestrial process, since no such large sources of energy were known. Third, for 25 years it furnished an entirely unsupported basis for vivid speculation, and inspiration for cartoon-strips. By 1930 supporting evidence began to appear in rapidly increasing quantities, and by 1943 had assumed such overwhelming convincing proportions that subsequently even the cartoon-strips were suppressed as a wartime security measure for it was feared that they would be revealing to an alert enemy.

Radioactivity and Atomic Structure. First discovered in 1896, the phenomena of radioactivity have played leading parts in the discovery of the general laws of atomic structure and in the verification of the equivalence of mass and energy. Although the first observed phenomenon of radioactivity was the blackening of photographic plates by the radiations from uranium minerals, the phenomenon of the greatest scientific value is the ability to ionize gases, which quality was discovered shortly thereafter through the observed loss of charge from an electroscope when in the proximity of uranium salts. (The same thing would happen to a storage battery if sufficient radioactive material were placed near it.) Since that time, the rate of discharge of an electroscope has served as a measure of intensity of radioactivity; in fact, nearly all present-day instruments for studying radioactivity depend either directly or indirectly upon this ionization effect.

Studies of absorption and other phenomena have shown that three different types of radiation are given off by radioactive substances:

1. Alpha particles, which are high-speed ionized helium atoms (actually the nuclei of helium atoms).
2. Beta particles, which are high-speed electrons.
3. Gamma rays, which are electromagnetic radiations similar to X rays.

Of these, only gamma rays properly are called radiations, and even they act like particles because of their extremely short wave length. Even though alpha and beta particles are less penetrating than gamma rays, they have enormous kinetic energies for particles of an atomic size, energies thousands of times greater than the kinetic energies which the molecules of a gas have by reason of their thermal motion, and thousands of times greater than the energy changes in chemical reactions. It was for this reason that Einstein suggested that studies of radioactivity might reveal the equivalence of mass and energy, as it has.

The Atom. As presently understood in the light of studies of radioactivity, every atom consists of a small heavy nucleus approximately 10^{-12} centimeter in diameter, surrounded by a largely empty region 10^{-8} centimeter in diameter in which electrons move about somewhat like the planets about the sun. The nucleus carries an integral number of positive charges, each 1.6×10^{-19} coulomb in size. Each electron carries one negative charge of this same size, and the number of electrons circulating around the nucleus is equal to the number of positive charges on the nucleus, so that the atom as a whole has a net charge of zero.

The number of positive charges in the nucleus is called the atomic number, Z, which determines the number of electrons in the extranuclear structure, and this in turn determines the chemical properties of the atom. Thus, all the atoms of a given chemical element have the same atomic number, and conversely all atoms having the same atomic number are atoms of the same element regardless of possible differences in their nuclear structure. The extranuclear electrons in an atom arrange themselves in successive shells according to well-established laws. Optical spectra arise from disturbances in the outer part of this electron structure; X rays arise from disturbances of the electrons close to the nucleus. The chemical properties of an atom depend upon the outermost electrons, and the formation of chemical compounds is accompanied by minor rearrangements of these outer electronic structures. Consequently, when energy is obtained by oxidation, combustion, explosion, or other chemical process, it is obtained at the expense of these structures so that the arrangement of the electrons in the products of the process must be one of lowered energy content. The atomic nuclei are not affected by any chemical process.

Not only is the positive charge on a nucleus always an integral number of electronic charges, but the mass of the nucleus is always approximately a whole number times a fundamental unit of mass which is almost the mass of a proton, the nucleus of a hydrogen atom. This whole number is called the mass number, A, and always is at least twice as great as the atomic number except in the cases of hydrogen and a rare isotope of helium. Since the mass of a proton is about 1,800 times that of an electron, the mass of the nucleus is very nearly the whole mass of the atom.

Radioactivity and Nuclear Change. If an atom emits an alpha particle (which has an atomic number of 2 and a mass number of 4) it becomes an atom of a different element with an atomic number lower by 2 and a mass number lower by 4. The emission by a nucleus of a beta particle increases the atomic number by one and leaves the mass number unaltered. In some cases these changes are accompanied by the emission of gamma rays. Elements which spontaneously change or "disintegrate" in these ways are unstable and are described as being "radioactive." The only natural elements which exhibit this property of emitting alpha or beta particles are with but minor exceptions those of very high atomic numbers and mass numbers, such as uranium, thorium, radium, and actinium which are the elements known to have the most complicated nuclear structures. All the atoms of a particular radioactive species have the same probability of disintegrating in a given time, so that an appreciable sample of radioactive material, containing many millions of atoms, always changes or disintegrates at the same rate. This rate of change is expressed in terms of the "half-life," which is the time required for half the atoms initially present to disintegrate, a time which evidently is constant for any particular atomic species. Half-lives of radioactive materials range from fractions of a second for the most unstable to billions of years for those which are but slightly unstable. Often the "offspring" nucleus, like the "parent" nucleus, is itself radioactive and so on down the line for successive generations of nuclei until finally a stable one is reached. There are three such families, or series, comprising all together about 40 different radioactive species. The radium series starts from one isotope of uranium, the actinium series starts from another isotope of uranium, and the thorium series starts from thorium. The final product of each series, after 10 or 12 successive emissions of alpha and beta particles, is a stable isotope of lead.

The Neutron. Neutrons are uncharged, a characteristic which distinguishes them from other subatomic particles, delayed their discovery until 1932, makes them very penetrating, makes them impossible to observe directly, and makes them of cardinal importance as agents in nuclear change. Although an atom in its normal state also is uncharged, it is 10,000 times as large as a neutron and consists of a complex "solar" system as previously mentioned of negatively charged electrons widely spaced about a positively charged nucleus. Charged particles (such as protons, electrons, or alpha particles) and electromagnetic radiations (such as gamma rays) lose energy as they pass through matter, and exert electric forces which ionize atoms of the material through which they pass. The neutron is unaffected by such forces; it is affected only by a very short-range force—that is, a force which comes into play when the neutron comes very close to an atomic nucleus. This is the kind of force which holds a nucleus together in spite of the mutual repulsion of the positive charges in it. Consequently a free neutron continues unchecked on its way until it makes a head-on collision with an atomic nucleus. The uncharged nature of the neutron makes it difficult to control as well as to detect. It will not respond to the electric or magnetic fields with which charged particles can be controlled. Furthermore, free neutrons can be obtained only from nuclear disintegrations; there is no natural supply. The only known way of controlling free neutrons is to put nuclei in their way so that they will be slowed, deflected, or absorbed by collisions. These effects are of the greatest practical importance in the atomic bomb project.

Nuclear Structure. The old idea that all elements are made up of but a few fundamental particles now is firmly established; present understanding indicating three: the neutron, the proton, and the electron. Also according to present views, the nuclei of all atomic species are made up of neutrons and protons; the number of protons equal to the atomic number, Z; the number of neutrons (N) being equal to the difference between the mass number and the atomic number, or $A-Z$. Two sets of forces act on these particles; ordinary coulomb forces of repulsion between the positive charges; and very short-range forces of attraction between all the particles, which forces as yet only partly are understood. Suffice it to say that the combined effects of these attractive and repulsive forces are such that only certain combinations of neutrons and protons are stable. If the neutrons and protons are few in number, stability occurs when their numbers are about equal. For larger nuclei, the proportion of neutrons required for stability is greater. Finally, at the end of the periodic table, where the number of protons is more than 90 and the number of neutrons nearly 150, no completely stable nuclei exist, although, as evidenced by their very long half-lives, some of the heavy nuclei are almost stable. When an unstable nucleus is formed artificially by adding an extra neutron or proton, a change to stable form eventually takes place. Strangely enough, this is not accomplished by ejecting a proton or a neutron, but by ejecting a positron or an electron. In other words, the mass number remains the same, but the atomic number changes. The stability conditions are not very critical, so that for a given mass number (given total number of protons and neutrons) as many as three or five different stable arrangements of protons and neutrons may exist, giving several isobars. For a given atomic number (given number of protons) conditions can vary still more widely, so that some of the heavy elements have as many as 10 or 12 stable isotopes. Some 250 stable nuclei had been identified, ranging in mass number from 1 to 238 and in atomic number from 1 to 92, as of 1940; now, the range has been extended to 239 and 95 respectively.

The theory of nuclear forces still is incomplete, but has been developed on quantum-mechanical principles sufficiently to explain not only the foregoing observations, but also more detailed empirical data on artificial radioactivity and on the differences between nuclei with odd and with even mass numbers.

ENERGY CONSIDERATIONS

That work must be done on a stable system to break it up is a general principle of physics. Thus energy must be supplied to separate into its constituent particles a stable assemblage of protons and neutrons. If energy and mass really are equivalent, the total mass of a stable nucleus should be less than the total mass of the separate protons and neutrons that make it up. This mass difference, then, should be equivalent to the energy required to disrupt the nucleus completely, and is called the "binding energy." Consider the alpha particle as an example. It is stable. As its mass number is 4 and its atomic number is 2, it consists of 2 protons and 2 neutrons. As the mass of a proton is 1.00758 and that of a neutron is 1.00893, the total of the masses of the constituents is 4.03302 whereas the mass of the helium nucleus itself is but 4.00280. Neglecting the last two decimal places, this gives a difference of 0.030 mass unit as representing the "binding energy" of the protons and neutrons in the helium nucleus. This seems like an insignificantly small value, but, by Einstein's equation $E=mc^2$, it figures out to 190,000 kilowatt-hours of energy! Hence, conversely, if free protons and neutrons could be assembled into helium nuclei, this amount of energy would be released. Thus, it evidently was worth while to explore the possibility of getting energy by combining protons and neutrons, or by transmuting one kind of nucleus into another. The first such nuclear change was accomplished in 1932 in an experiment where a target of lithium was bombarded with protons of 700-kv energy and alpha particles ejected from the target as the result of the bombardment. The change resulted in the loss of 0.0185 unit of mass and released energy in the alpha particles of approximately 17 million electron-volts.

This might well lead to the question as to why atomic power plants did not spring up at once in the 1930's. After all, if 2.76×10^{-5} erg could be gotten from an atom of lithium struck by a proton, why should it not be expected that a half-million kilowatt-hours could be gotten by combining a gram of hydrogen with seven grams of lithium?

It looks better than burning coal. The difficulties, of course, lie in the production of the high-speed protons and in controlling the energy produced. The laboratory experiments reported were conducted with infinitesimal quantities of material, fractions of micrograms rather than grams, or pounds. Also, there was the little matter of using up more energy in these experiments in the energizing of the protons than was generated by the nuclear reaction.

III. Chronology of Bomb Research

THE following chronology of selected events especially pertintent to the realization of the alchemists' dream of the centuries is intended to present only a typical cross section of the manifold aspects of the war-stimulated nuclear research. Inevitably, in a brief report on so ramified a project, many important aspects of the famous Manhattan Project and its predecessor and related enterprises are not reported here. Continuing security regulations, too, still prevent discussion of some of the aspects which would be of especial interest to engineers.

1919. Discovery made that high-energy alpha particles could cause an alteration in the nucleus of an ordinary element. Specifically, a few atoms of nitrogen were changed into atoms of oxygen by bombardment with alpha particles. Prior to this no one had succeeded in disturbing the stability of ordinary nuclei or in affecting the rates of disintegration of those that were naturally radioactive.

1930–32. Research in United States, Britain, France, and Germany leads to discovery, identification, and evolution of protons, neutrons, deuterons, and positrons.

1934. Fermi and colleagues first study the results of neutron bombardment of uranium, noting the formation of an unstable nucleus which by subsequent emission of an electron became a stable nucleus one unit higher in mass number and atomic number than the initial target nucleus. Results not properly interpreted until several years later.

January 26, 1939. At a conference on theoretical physics in Washington, D. C., Bohr of Denmark and Fermi of Columbia University discuss possibility of chain reaction related to the currently predicted fission of uranium and resultant release of neutrons. Several laboratories stimulated into action in effort to confirm or disprove.

February 1939. Fission confirmed by research reports from various laboratories.

March 1939. Fermi reported to Navy Department in conference that achievement of controllable reaction by slow neutrons or explosive reaction by fast neutrons seemed possible, although uncertain on basis of meager information available.

July 1939. Matter finally brought to attention of President Roosevelt by Alexander Sachs of New York, N. Y., acting on behalf of various nuclear scientists, resulting in appointment of Advisory Committee on Uranium, under the chairmanship of Doctor Lyman J. Briggs, director of the Bureau of Standards.

October 21, 1939. First meeting of Advisory Committee on Uranium.

November 1, 1939. First report of uranium advisory committee included recommendation for procurement of 4 tons of graphite and 50 tons of uranium oxide for measurement of neutron-absorption susceptibility or "cross section" of carbon. Also specifically mentioned possibility of both atomic power and an atomic bomb.

February 20, 1940. First transfer of funds ($6,000) from Army and Navy for purchase of materials for the researches recommended by the uranium advisory committee.

February 1940. First small amounts of concentrated fractions of the three uranium isotopes of masses 234, 235, and 238 obtained by use of mass spectrometer. Cyclotron tests soon demonstrated that U-235 was the isotope susceptible to fission by thermal (relatively slow) neutrons.

April 28, 1940. At second meeting of uranium advisory committee, two important new factors were reported:

1. Discovery that the uranium fission caused by neutrons of thermal (low) velocity occurred only in the U-235 isotope.

2. That a large section of Kaiser Wilhelm Institute in Berlin had been set aside for uranium research.

June 1, 1940. By this time, all the following information was generally known, abroad as well as in the United States:

1. That three elements—uranium, thorium, and protoactinium—when bombarded by neutrons sometimes split into approximately equal fragments, and that these fragments were isotopes of elements in the middle of the periodic table, ranging from selenium (atomic number 34) to lanthanum (atomic number 57).

2. That most of these fission fragments were unstable, subject to relatively rapid decay through radioactivity by successive emission of beta particles, thus progressively changing through a series of elements to various relatively stable forms.

3. That these fission fragments had enormous kinetic energy.

4. That fission of thorium and protoactinium was caused only by fast neutrons (velocities of the order of thousands of miles per second).

5. That fission in uranium could be produced by slow (so-called thermal-velocity) neutrons as well as by fast neutrons; specifically, that thermal neutrons caused fission in one isotope, U-235, but not in the other, U-238, and that fast neutrons had a lower probability of causing fission in U-235 than thermal neutrons.

6. That at certain neutron speeds there was a large neutron-capture susceptibility "cross section" in U-238 producing U-239 but not fission.

7. That the energy released per fission of a uranium nucleus was approximately 200 million electron volts.

8. That high-speed neutrons were emitted in the process of fission.

9. That the average number of neutrons released per fission was somewhere between one and three.

10. That high-speed neutrons could lose energy by inelastic collision with uranium nuclei without any nuclear reaction taking place.

11. That most of this information was consistent with the semi-empirical theory of nuclear structure worked out by Bohr and Wheeler and others; this suggested that predictions based on this theory had a fair chance of success.

12. It was realized that capture of neutrons by U-238 probably would lead by two successive beta-ray emissions to the formation of a nucleus of atomic number 94 and mass 239 (later identified and called plutonium).

June 1940. Advisory Committee on Uranium reconstituted as a subcommittee of the newly organized National Defense Research Committee.

November 8, 1940. First NDRC contract for uranium research issued to Columbia University for $40,000.

May 1941. Formation of plutonium ("element 94") reported as result of neutron bombardment of uranium 238.

July 1941. First lattice structure of graphite and uranium set up at Columbia University, an 8-foot graphite cube containing about 7 tons of uranium oxide in iron containers distributed at equal intervals throughout the graphite. Preliminary measurements made in August confirming possibility of controlled chain reaction. Experiments continued with larger structures of similar nature.

July 1, 1941. First Office of Scientific Research and Development research contract calling specifically for study of possibilities of gaseous diffusion method of isotope separation. Work continued through spring of 1945, resulting in huge diffusion separation plants at Oak Ridge, Tenn.

December 1941. By this time 16 uranium research contracts with research organizations had been executed by NDRC, totaling some $300,000. Only few grams of uranium metal and a few pounds of highly impure pyrophoric powder in existence in United States. Metal cost, $1,000 per pound. Stimulated by British reports of German activity in uranium research, the Office of Scientific Research and Development on December 6 decided upon an unlimited "all-out" effort in the nuclear research program.

Because of the skillful theoretical interpretation of the meager results of the limited research work possible at that time, it could be said that by the end of 1941 the general theory of the chain reaction for slow neutrons was understood almost completely, although numerical constants and technological possibilities still remained uncertain. Appreciable progress also had been made on the theory of a fast neutron reaction in U-235. The proposal had been made that the uranium chain reaction be used for the production of plutonium which was thought to have explosive possibilities appropriate for a "super bomb." Methods of isotope separation had been demonstrated experimentally "in principle" on a laboratory basis with minute quantities and makeshift equipment. This included the mass spectrograph, the centrifuge method, the gaseous diffusion method, the thermal diffusion method, and a debate on the practicality of an electromagnetic method. Although the theoretical understanding was crystallizing rapidly by the end of 1941, very little progress had been made by that time in the production of materials for use in a chain-reacting system. Much progress had been made, however, on analysis. The development of sufficiently accurate methods of chemical analysis of the materials used was a problem of the first magnitude throughout the history of the project, although sometimes overshadowed by the more spectacular problems encountered.

March 9, 1942. OSRD report to President Roosevelt reflected optimism, but stressed tentative nature of conclusions. Suggested that the Army be brought into the project during the summer of 1942 for the construction of full-scale production plants.

June 17, 1942. OSRD report to President indicated conclusively that:

1. A few kilograms of U-235 or plutonium could be detonated with an explosive force equivalent to that of several thousand tons of TNT.

2. Four feasible methods of preparing fissionable material had been developed.

3. Production plants of considerable size could be designed and built.

4. Full-scale plant operation seemed possible soon enough to be of military significance, if supported by adequate funds and priorities.

August 13, 1942. Now famous "Manhattan District" of United States Army Corps of Engineers officially established under innocuous label "Development of Substitute Materials" (DSM), to take over first the procurement and engineering phases of the rapidly expanding project, and later to take over also administration of the various research contracts.

November 5, 1942. Construction of electromagnetic plant at Clinton, Tenn., authorized.

November 1942. Site chosen at Los Alamos, N. Mex., for laboratory to concentrate on design and development of atomic bombs; selection of scientific staff and preparation of construction plans under way for master laboratory.

December 1942. First self-sustaining nuclear chain reaction ever initiated by human beings established December 2. Pile constructed of graphite, uranium oxide, and uranium metal, operated first at 1/2 watt, a few days later at 200 watts. Conclusively proved practicability of controlled chain reaction. Critical size for self-induced chain reaction found to be somewhat smaller than calculated.

Production of raw material improved to extent that uranium metal was available at several hundred pounds per day and cost was down to $22 per pound as compared with $1,000 per pound a year previous.

Total of 500 micrograms of plutonium has been made with cyclotron and separated chemically from uranium and fission products. Enough learned of chemistry of plutonium to indicate possibility of separation on a large scale.

No great advance made in 1942 on bomb theory, but calculations were checked, and experiments with fast neutrons were extended. If anything, the prospects for a successful bomb looked more favorable than a year earlier.

Problems of large-scale separation of uranium isotopes by gaseous diffusion process now well defined by results of research.

January 1943. Plans for pilot plant for development of plutonium production methods well along; to be built at Clinton, Tenn.

Plans for vast plutonium production plant formulated for construction at Hanford, Wash., on a 1,000-square-mile reservation. The magnitude of the project was enormous. Laboratory experiments and calculations had indicated that the production of one gram of plutonium a day corresponded to the generation of somewhere between 500 and 1,500 kw-hr of energy per day. Thus, a plant designed to produce a kilogram of plutonium a day would result in the release and necessary dissipation of 500,000 to 1,500,000 kw-hr of energy per day. The problem, therefore, was to design a plant of this capacity on the basis of laboratory experience with a pile that could operate at a power level of only 0.2 kw. As regards the plutonium separation work, which was equally important, it was necessary to draw plans for an extraction and purification plant which would separate some grams a day of plutonium from some tons of uranium, and such planning had to be based on information obtained by microchemical studies involving only half a milligram of plutonium. In peacetime, no engineer or scientist in his right mind would consider making such magnification in a single stage, and even in wartime only the possibility of achieving tremendously important results could justify it, and did. A site was chosen on the Columbia River at Hanford, where desert terrain provided plenty of elbow room and the Columbia River provided a cooling medium for the dissipation of huge amounts of energy to be released in the fission process.

Construction of gaseous diffusion separation plant at Clinton, Tenn., authorized. In successful operation by 1945. For the men working on gaseous diffusion it was a long pull from 1940 to 1945, not lightened by such exciting half-way marks as the first chain-reacting pile at Chicago. Perhaps more than any other group in the project, those who have worked on gaseous diffusion deserve credit for courage and persistence as well as scientific and technical ability. For security reasons, it is not possible to tell how they solved their problems—even in many cases found several solutions as insurance against failure in the plant. Work at Columbia University on the separation of isotopes by gaseous diffusion began in 1940, and by the end of 1942 the problems of large-scale separaion of uranium by this method had been well defined. The magnitude of the gaseous diffusion plant can be indicated by its requirement of some 30,000 miles of electrically welded gas-tight seams for gas chambers and ducts; 10 miles of control galleries mounting thousands of instruments.

April 1, 1943. Available information pertinent to design of atomic bomb preliminary and inaccurate. Further and extensive theoretical work on critical size and methods of detonation urgently needed.

April 14, 1943. Assembly of cyclotron started at Los Alamos bomb laboratory; first operation in early July 1943, by 1945 Los Alamos was without question the world's best equipped physics laboratory. At Los Alamos, the research and production results achieved elsewhere were guided and co-ordinated, and the bomb itself was evolved from tenuous theory to demonstrated fact.

May 1943. Correlation of entire project placed under Army control, ending the period of joint OSRD–Army control of the project.

June 7, 1943. Work on assembly of first production piles at Hanford plant begun. Work also under way on plutonium separation plant and a vast array of auxiliary facilities.

November 4, 1943. Clinton pile started, up to 500 kw within a few days; subsequently up to 800 kw and operated at this level until Spring 1944; later operated at more than 1,800 kw.

Clinton electromagnetic separation plant also started this month, and for a year was only production source of uranium 235. It was in large-scale production during the winter of 1944–45, producing U-235 of sufficient purity for use in bombs.

December 20, 1943. First slugs from chain-reacting pile at Clinton pilot plant enter Clinton separation plant; up to one third ton per day by February 1, 1944. The pile itself was simple both in principle and in practice. Not so the plutonium-separation plant. The step from the first chain-reacting pile to the Clinton pile was reasonably predictable; but a much greater and more uncertain step was required in the case of the separation process, for the Clinton separation plant was designed on the basis of experiments using only microgram amounts of plutonium. Nevertheless, the separation process worked!

February 1, 1944. 190 milligrams of plutonium delivered from Clinton separation plant to date; several grams by March 1. Efficiency of recovery, initially about 50 per cent, was above 80 per cent by June.

May 15, 1944. Uranium-and-heavy-water pile ready for test; by July 4, operating at 190 kw; by August 8, operating at 300 kw. Successful, but less susceptible to close control than uranium-and-graphite pile. Hence, plans for production plant cancelled.

Summer 1944. Thermal-diffusion production separation plant hastily built at Clinton, Tenn., to furnish enriched concentrates for processing through the electromagnetic separation plant to enhance its productivity of U-235.

September 1944. First production pile at Hanford plant in operation; second and third piles in operation by early months of 1945. Operation exceeded expectation.

July 16, 1945. World's first atomic bomb exploded in test on New Mexico desert, under scrutiny of Los Alamos laboratory scientists who developed it. Results: devastating, as expected.

August 5, 1945. First military use of atomic bomb; dropped on Hiroshima, Japan, by a B-29 of the 20th Air Force in the Mariannas.

August 10, 1945. Second atomic bomb dropped on a military target, at Nagasaki, Japan, was of different design.

August 14, 1945. Japan capitulates; action obviously precipitated by the atomic bombs, the result of a two-billion-dollar research and production program.

Statistical Methods in Quality Control

X. Classification of Defects and Quality Rating

A simple measure of quality in which the percentage ratio of defective units to total units is calculated usually is adequate for simple products where inspection covers only a few characteristics, but where many characteristics are involved the method is not satisfactory. This article discusses classification of defects according to seriousness and outlines methods of rating quality based upon such classification.

IN THE CONTINUOUS manufacture of any type of electric apparatus or equipment management often wishes to have the answer to such questions as: How good is the quality of current product? Is it as good as it should be? Is it better or poorer than last week's product? How are we doing compared with six months ago?

To get the answer to some of these questions usually does not require any special data. The data obtained in routine inspections often provide all that is needed. True, in day-to-day inspection work the information obtained in inspection too often is used merely for the purpose of sorting out unsatisfactory product units or for accepting or rejecting individual lots on a sampling basis. But if we make a chain use of these data, tabulating and summarizing them, we readily may get a running picture of quality and the answer to some of the questions which are of importance to those responsible for shop performance.

Consider a situation in which we are concerned with the quality of a product of thyratrons being produced more or less regularly at a rate of about 1,200 per week. As for many products, final inspection may consist of testing each unit for mechanical and electrical requirements, gauging critical dimensions, and examining each unit visually for defects in assembly, workmanship, and material. Based on these results, units found to contain defects, that is, failures to meet specified limits or accepted standards of good workmanship, are sorted out and returned to the operating department either for repair, rework, or scrap. This constitutes a 100-per-cent inspection by the method of attributes[1] and provides detailed information which can be used to indicate the quality of the product as it comes from the shop to the final inspector.

One simple measure of such quality would be given by computing the per cent defective, that is, the percentage ratio of defective units to total units. This is often satisfactory for very simple products where inspection covers only a few characteristics, such as screws inspected for dimensions and threading. But where many characteristics are involved, as for most electric apparatus, the value of per cent defective does not provide a very satisfactory yardstick of over-all quality for it fails to take into account that defects of different kinds are not equally serious. Thus for thyratrons an important defect such as an internal cross or ground should have greater weight than an unimportant one such as a slightly cracked base. The method of rating[2] to be considered in the following recognizes such differences in seriousness of defects, and makes use of a system of weighting defects according to their seriousness.

The system can be applied equally well to the results of 100-per-cent inspection whereby the rating reflects the quality of product as it comes from the production line, or to the results obtained from a sample inspection of the finished product whereby the rating may be taken to reflect the quality to the customer.

CLASSIFICATION OF DEFECTS

For present purposes the seriousness of a defect will be judged from the standpoint of the user, taking into account its potential effect on service performance and customer satisfaction. For a given product, a set of defect classes is adopted, each class being defined sufficiently well to assure substantial agreement among different individuals in the process of classifying individual defects. Two classes may be sufficient for some relatively simple products; for others three or four classes may be found desirable.

The principles perhaps can be outlined most readily by considering a simple two-fold classification of defects, designated "major" and "minor." These might be defined, for example, as follows:

Major defects = those that are likely to have a major effect on the operation or life of the unit under normal conditions of use.

Minor defects = those that will have little, if any, effect on operation or life.

A three-fold or four-fold classification would require, of course, a more expansive set of definitions with attention

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One of a series of articles prepared in the AIEE subcommittee on educational activities and sponsored by the AIEE subcommittee on statistical methods.

Personnel of the AIEE subcommittee on educational activities: J. Manuele, H. F. Dodge, A. I. Peterson, and R. E. Wareham.

Table I. Calculation of Three Measures of Quality

Week Ending	Number of Units Inspected	Number of Defective Units	Per Cent Defective	Number of Defects Found		Number of Demerits			Demerits-Per-Unit	Index (Standard = 1.9)
				Major	Minor	Major Defects	Minor Defects	Total		
September 1	1,120	39	3.5	17	29	850	290	1,140	1.02	0.54
8	1,310	90	6.9	27	74	1,350	740	2,090	1.60	0.84
15	1,390	111	8.0	80	45	4,000	450	4,450	3.20	1.68
22	1,240	60	4.8	24	44	1,200	440	1,640	1.32	0.69
29	1,460	117	8.0	7	123	350	1,230	1,580	1.08	0.57
October 6	1,510	155	10.3	73	115	3,650	1,150	4,800	3.18	1.67
13	1,130	105	9.3	43	86	2,150	860	3,010	2.66	1.40
20	1,260	100	7.9	34	81	1,700	810	2,510	1.99	1.05
27	1,020	103	10.1	11	104	550	1,040	1,590	1.56	0.82
November 3	1,330	184	13.8	37	190	1,850	1,900	3,750	2.82	1.48
10	1,410	135	9.6	42	121	2,100	1,210	3,310	2.35	1.24
17	1,250	153	12.2	46	140	2,300	1,400	3,700	2.96	1.56
24	910	98	10.8	57	53	2,850	530	3,380	3.71	1.95

perhaps to different degrees of probability of causing trouble with respect to such things as safety, operation, life, maintenance, and appearance.[2]

Having chosen a set of definitions, the next step is to make a list of all kinds of defects, electrical, mechanical, assembly, finish, and so forth, that may be encountered in the inspections under consideration and then classify them individually in accordance with those definitions. A partial defect classification for thyratrons might appear somewhat as follows:

Defect Classification	Class
Cold discharge test; voltage outside specified limits:	
Deviates from limit by more than 20 per cent of limit value	Major
Deviates from limit by 20 per cent or less of limit value	Minor
Bulb contains metal parts	Major
Open filament-support weld	Major
Elements out of alignment:	
Likely to cause failure	Major
Affecting appearance only	Minor
Base cracked	Minor
and so forth	

Here it is noticed that the same type of defect, such as failure to meet limits specified for a particular test, may be given more than one classification according to the degree of departure from the limits.

It remains to choose a suitable set of weights for the two classes. Here only the relative weights are important; the absolute scale of weights is immaterial. The choice is largely empirical and depends in any case on engineering judgment.

QUALITY RATE: DEMERITS-PER-UNIT

Suppose, now, a number of units are inspected in accordance with a definite prescribed procedure. Each observed defect may be weighted by assigning to it a number of demerits, such weight to reflect relative seriousness as contemplated in the classification of defects. All kinds of defects falling in the same class thus are assigned the same number of demerits.

All defects found are counted for rating purposes even though two or more are found on a single unit. The only exception is where one defect is the cause of others. In this case only the most serious one of the mutually dependent defects is counted.

Quality then is expressed in terms of "demerits-per-unit." For the simple case where *all* inspected units are inspected for *all* characteristics under consideration (number inspected, n, is the same for all characteristics), the quality rating in demerits-per-unit is merely the sum of the demerits assessed against defects found, divided by the number of units inspected.

Suppose, for purposes of illustration, we use demerit weights of 50 and 10 respectively for major and minor defects. Let us say that the results of a 100-per-cent inspection of thyratrons over a period of several weeks were as shown in Table I. The method of calculating the rate is indicated in Table I. At the top of Figure 1 is shown a curve of week-by-week values of per cent defective. At the center of Figure 1 is shown the quality rating curve for the demerits-per-unit measure of quality. We note that the demerits-per-unit rating reflects quite a different picture from the per cent defective curve, especially in the third and fifth weeks. In the third week an abnormally high proportion of the observed defects were of major classification, whereas in the fifth week the situation was reversed—the defects were mostly of minor classification.

A little reflection will show that the demerits-per-unit rating is merely a *weighted* measure of degree of nonconformance to requirements. The sum total of specified requirements is used as a convenient standard of reference. With no defects (the best performance attainable relative to this standard), the demerits-per-unit value is zero. Thus, quality performance is measured by a weighted sum of undesirable items, that is, failures to meet requirements.

QUALITY CONTROL CHART

A quality control chart can be constructed for the demerits-per-unit measure of quality in much the same way as for values of per cent defective. For example, suppose that a standard or expected level of quality based on past experience plus engineering considerations is set at a level of 1.9 demerits-per-unit. This is shown as a dashed line in Figure 1. Three-sigma control limits for this measure may be established from formulas that already have been published[2]:

$$\sigma_{D_u} = \sqrt{\frac{w_1{}^2(\bar{d}_u)_1 + w_2{}^2(\bar{d}_u)_2}{n}}$$

and

$$\text{3-sigma control limits} = (D_u)_s \pm 3\sqrt{\frac{w\ _1\bar{d}_u)_1 + w_2{}^2(\bar{d}_u)_2}{n}}$$

where

σ_{D_u} = standard deviation of demerits-per-unit
$(D_u)_s$ = standard value of demerits-per-unit
w_1, w_2 = demerit weight for major defects and minor defects, respectively
$(\bar{d}_u)_1$, $(\bar{d}_u)_2$ = expected defects-per-unit, for major defects and minor defects, respectively
n = number of units inspected

For the problem cited $(D_u)_s = 1.9$, $w_1 = 50$, $w_2 = 10$, $(\bar{d}_u)_1 = 0.026$, $(\bar{d}_u)_2 = 0.060$, which gives

$$\sigma_{D_u} = \sqrt{\frac{71.0}{n}}$$

The control limits of such a chart, shown as dotted lines in Figure 1, enable one to see at a glance whether quality at any particular time differs from the standard quality level by an amount that warrants special attention and corrective action.

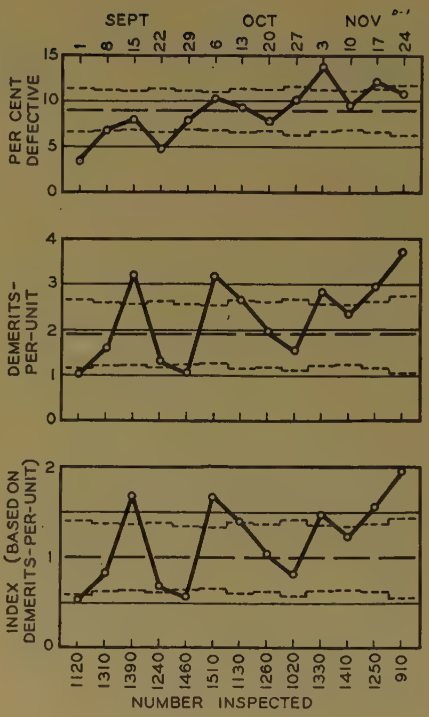

Figure 1. Comparison of three measures of quality

Glenn L. Martin photo

An instrument gauge of particular value for the inspection of the bonds between the laminar layers of laminated materials as well as for the inspection of single sheets. The gauge operates on the pressure principle

QUALITY RATE EXPRESSED AS AN INDEX

Instead of expressing quality directly in terms of demerits-per-unit, it sometimes may be convenient to express it in the form of an index, namely

$$\text{Index} = \frac{\text{Observed demerits-per-unit}}{\text{Expected demerits-per-unit}}$$

which gives a simple ratio of the observed to the expected number of demerits-per-unit. This gives a form of statistical index similar to that used in other fields, such as for cost of living, coal production, and so forth, in which a current computed value is compared with a standard reference value. The numerical value of the index indicates directly the relation of the observed to the expected degree of nonconformance to requirements, that is, whether it is half, equal to, or twice as great. Such an index is shown pictorially at the bottom of Figure 1. Here the value of "expected demerits-per-unit" is taken to be 1.9, and it will be noted that the curve is identical with that for "demerits-per-unit," except for a simple conversion of scale.

More complex methods of rating over-all quality can be devised, of course, to meet specific situations, but the method outlined here has the advantage of simplicity and can be understood by both supervision and workers.

REFERENCES

1. Statistical Methods in Quality Control II. Two Kinds of Measurement—Variables and Attributes. *Electrical Engineering*, volume 64, July 1945, pages 249–50.

2. A Method of Rating Manufactured Product, H. F. Dodge. *Bell System Technical Journal*, volume 7, April 1928, pages 350–8.

INSTITUTE ACTIVITIES

South West District Meeting to Be Held in San Antonio, Tex., April 16-18

A varied program has been arranged for the South West District meeting and Student Branch convention to be held in San Antonio, Tex., April 16–18, 1946. The program will include several technical sessions, some general sessions, interesting inspection trips, and entertainment. In addition luncheon meetings are planned for the District executive committee and for the District committee on Student activities. Meeting headquarters will be in the Plaza Hotel.

Special attention is called to the general session to be conducted by the planning and co-ordination committee. This session will afford an opportunity for free expression of opinion by the membership regarding activities of the Institute. Of especial interest also will be the session on electrical problems in Mexico which now is included entirely in the South West District. This session will be conducted by members from Mexico.

SPORTS AND ENTERTAINMENT

San Antonio has some fine golf courses as well as numerous tennis courts and arrangements will be made for those wishing to play golf or tennis.

On Tuesday evening a stag smoker and supper will be held for which there will be a reasonable charge.

A special feature of the meeting will be the banquet on Wednesday evening to which all, and especially the women, are invited. It will take place at La Villita, picturesque restoration of the early San Antonio settlement, which lies within the shadow of the Plaza Hotel. AIEE President William E. Wickenden will deliver the principal address of the evening. The entertainment will be provided by Mexican dancers and singers. The banquet should prove to be an outstanding event and all are sure to enjoy the novel Mexican atmosphere. Tickets may be secured at the registration desk.

WOMEN'S ENTERTAINMENT

A special committee of women under the leadership of Mrs. N. B. Gussett has been formed to insure an interesting and enjoyable time for the women attending the meeting. The entertainment as planned includes visits to the stores of San Antonio, bridge parties, trips to the famous Missions, to the Alamo, and to the Old Spanish Governor's palace. Further details may be secured upon registration.

RANDOLPH FIELD TRIP

One of the outstanding inspection trips arranged for those attending the meeting is the projected visit to Randolph Field, the "West Point of the Air." The field was closed to visitors during the war and the many changes and improvements which were made will be of great interest even to those who have been there before. Women, also are invited.

Arrangements may be made at the registration desk for trips to any industry or to any of the many historic and scenic attractions in which San Antonio abounds.

HOTEL RESERVATIONS

It is imperative that all members make their hotel reservations early, at least 30 days in advance, by writing directly to the hotel. All the hotels listed in Table I are within a short distance of the Plaza Hotel. If any difficulty is encountered communicate with O. T. Lodal, chairman of the hotels committee.

Table I. Hotel Rates

	Prevailing Rates	
	Single	**Double**
Plaza, Headquarters Hotel	$2.50–$5.00	$3.50–$7.50
St. Anthony	2.50– 8.00	4.00 up
White-Plaza	2.50– 6.00	3.50– 8.00
Gunter	2.50– 5.00	3.50–12.00
Robert E. Lee	2.00– 3.50	3.50– 6.00
Blue Bonnet	2.00– 3.00	3.50– 6.00

ADVANCE REGISTRATION

Members of the District and others who receive a mailed announcement of the meeting should fill in and return the advance registration card promptly. This will save time at the registration desk and will aid the committee greatly.

The Alamo, famed "Cradle of Texas Liberty," is located in San Antonio, Tex., where the South West District meeting will be held, April 16–18

Tentative Technical Program and Meeting Features

- **PAMPHLET reproductions of authors' manuscripts of the numbered papers listed in the program may be obtained.**
- **ABSTRACTS of most numbered papers appear on page 130 of this issue.**
- **PRICES and instructions for procuring advance copies of these papers accompany the abstracts. Mail orders are advisable, particularly from out-of-town members, as an adequate supply of each paper at the meeting cannot be assured. Only numbered papers are available in pamphlet form.**
- **PAPERS regularly approved by the technical program committee ultimately will be published in "Transactions"; many will appear in "Electrical Engineering."**

Tuesday, April 16

9:00 a.m. Registration

10:00 a.m. General Session

Address of welcome: **Honorable Gus B. Mauermann,** mayor of San Antonio

Presentation of welcome from Mexico

Address: The Institute Today. **H. H. Henline,** AIEE secretary

Address: Tomorrow's Engineering Developments. **M. W. Smith,** vice-president in charge of engineering, Westinghouse Electric Corporation

Address: Engineering Education for Postwar Problems. **A. S. Langsdorf,** dean of engineering and architecture, Washington University

2:00 p.m. Communication

DP.* Some Observations on German Research. **R. S. Glasgow,** Washington University

DP.* Plans and Progress with Radio Relay for a Domestic Telegraph Plant. **F. B. Bramhall,** Western Union Telegraph Company

DP.* Radar for Bombing. **K. E. Gould,** Bell Telephone Laboratories, Inc.

2:00 p.m. Power

DP.* Power Line Carrier for Relaying, Telemetering, Supervisory, and Point-to-Point Communication. **S. C. Leyland,** Westinghouse Electric Corporation

46-83. Operating Experience with Distance Ground Relays. **W. A. Wolfe,** Kansas Gas and Electric Company

46-80. A New Electronic Timing Relay for Reducing Outages on Power Circuits. **F. S. Dloughy,** Oklahoma Gas and Electric Company

DP.* Electrical Power Generation for Water Works Auxiliary Service. **H. F. Lutz,** Black and Veatch, Consulting Engineers

46-82. Some Problems of Distribution Engineering. **R. M. Walker,** El Paso Electric Company

7:00 p.m. Stag Supper and Smoker

Entertainment
Place to be announced later

Wednesday, April 17

9:00 a.m. General Session

Conference on Institute activities, conducted by planning and co-ordination committee

An opportunity for members to participate in a discussion of Institute activities

Final comments. **E. B. Robertson,** past president, Texas Society of Professional Engineers

11:00 a.m. Technical Session

DP.* Some Economic Aspects of the Advance of Industry in the Southwest. **R. A. Mulholland,** consulting engineer

DP.* Supersonic Sharpshooters. **H. H. Hickerson,** Boeing Airplane Company

12:00 noon. Luncheon meeting of Student Branch counselors

2:00 p.m. Inspection trip to Randolph Field

Ladies are included in this trip which will leave the south entrance of the Plaza Hotel. Cars will be provided for those who do not have a means of transportation.

7:00 p.m. Meeting Banquet

Address: **Doctor W. E. Wickenden,** president, AIEE

Entertainment by Mexican singers and dancers

All are invited.

Thursday, April 18

9:00 a.m. Petroleum Industry Applications

DP.* Power Distribution Systems for Oil Field Pumping. **W. C. Bloomquist, J. N. Poore,** General Electric Company

46-81. Modern Diesel-Electric Drilling Rig Equipment. **T. R. Rhea,** General Electric Company

DP.* Magnesium for Cathodic Protection. **J. R. James,** The Dow Chemical Company

9:00 a.m. Selected Topics

DP.* Rural Electrification. **W. B. Bigelow,** Rural Electrification Administration

DP.* New Developments and Improvements in the Design and Manufacture of Electric Equipment. **P. E. Benner,** General Electric Company

DP.* Banking Distribution Transformers; Advantages and Methods. **J. S. Parsons,** Westinghouse Electric Corporation

DP.* An Electronic Moment Indicator. **R. B. Basham,** Consolidated-Vultee Aircraft Corporation

DP.* Power Development in the Freeport–Velasco Area of Texas. **N. D. Griswold,** Dow Chemical Company

12:00 noon. Luncheon meeting of District executive committee

2:30 p.m. Electrical Problems in Mexico

The following papers have been prepared by several members of the Mexico Section as joint authors. Much of the information contained in them will be of value to the Mexican Government as well as to private concerns in Mexico. They are presented by the Section.

DP.* Electrification Program of the Mexican Republic. Preparation of paper directed by **Basil Nikiforoff,** Mexican Light and Power Company

DP.* Industrialization of Mexico. Preparation of paper directed by **G. David Roldan,** National Economy Bureau

DP.* The Planning of an Electric Equipment Manufacturing Plant in Mexico. Preparation of paper directed by **Eduardo Luque D., Jose Rafael Bejarano,** Industria Electrica

2:30 p.m. Student Session

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*DP: District paper; no advance copies are available; not intended for publication in *Transactions.*

No registration fee will be charged for members, Enrolled Students, or immediate families of members. A registration fee of two dollars will be charged of all nonmembers attending.

COMMITTEES

District Meeting:

R. W. Warner, vice-president, South West District; S. R. Friedsam, District secretary; H. P. Heafer; R. C. Horn; E. B. Robertson.

Chairmen of Subcommittees on Arrangements:

N. B. Gussett, general program; A. W. Stariton, meetings and papers; V. H. Braunig, entertainment; O. T. Lodal, hotels and registration; R. J. Foley, transportation and inspection trips; W. F. Helwig, student activities; Mrs. N. B. Gussett, women's entertainment.

Asheville, N. C., Locale of Southern District Meeting

An outstanding technical program is being planned to highlight the Southern District meeting which will be held in Asheville, N. C., on May 14–16, 1946. Meeting headquarters will be the Grove Park Inn, headquarters for the summer convention in 1931. The program will include a symposium on textiles, of special interest to the Southern District because its area contains nearly 75 per cent of all the spindles in the United States.

Two afternoons are being reserved exclusively for recreation and inspection trips. Asheville has a number of attractions for women, including the Biltmore House and Gardens, and the Biltmore Industries, as well as many short scenic trips through the mountains. Five golf courses also are within easy reach. The inspection trips will include the Enka Rayon Plant, the Ecusta Paper Company, manufacturer of cigarette paper, the Aluminum Company's new Glenville hydroelectric plant with 1,150 feet head, and the 80,000-kw Cliffside steam plant of the Duke Power Company which is undergoing a 60,000-kw addition. The board of directors of the Institute will hold its May meeting concurrently with the afternoon meeting on May 14.

Arrangements for the meeting are being made by a committee of the Southern District, of which H. W. Oetinger (M '35) and J. F. Rader (M '40) are cochairmen.

North Eastern District to Meet in Buffalo, N. Y.

Preparations are now in process for a meeting of the North Eastern District to be held in Buffalo, N. Y., April 24–26, 1946, with meeting headquarters in the Hotel Statler. As this will be the first postwar meeting of the District the local committee plans to include many outstanding features on the program.

Nine technical sessions will deal with the following subject matter: power systems, transmission and distribution, electronics, aviation, industrial applications, aviation and transportation, lighting, war developments, and communication, in addition to a conference on quality control. Some of the inspection trips will be correlated so that the equipment described may be seen in operation. Tentatively scheduled for inspection are the Cornell University wind tunnel at the Curtiss-Wright plant, Huntley station, Schoelkopf station, one of the aircraft plants, and Bethlehem Steel Corporation.

Schoelkopf station of the Niagara Falls Power Company which is scheduled for inspection during the North Eastern District meeting, April 24–26

Evenings during the meeting will be devoted to entertainment, and as a large number of women are expected to be present arrangements are being made to make their visit an enjoyable one. Among the entertainment features will be a social hour and informal banquet on April 24 and a smoker on April 25. There will be an opportunity for dancing every evening during the meeting.

Arrangements are being made by a committee with T. J. Brosnan (M'34), chairman, and W. S. Hill (M'30), chairman of the local technical program committee.

Record-Breaking Attendance Distinguishes Winter Convention

Unprecedented attendance marked the first of the AIEE postwar conventions, held in New York, N. Y., January 21–25, 1946. Registration reached the all-time high of 2,624, topping the previous record registration of 1,931 persons at Philadelphia, Pa., in January 1941. A fuller program of social activities also reflected the change from wartime to peacetime.

The aftermath of war was still apparent however, in the convention program. Two sessions on radar, a conference on new industrial uses of electronics resulting from wartime developments, a symposium on nuclear physics, and the addresses delivered at the general session and a joint AIEE-IRE meeting, both of which dealt with atomic energy, were a reminder of the recent conflict.

Of the 14 technical sessions, two were concerned with protective devices, two with instruments and measurements, two with air transportation, and two with electric machinery. Communications, relays, welding, power transmission, and hydroelectric systems also were the subjects of sessions. Others of the nine conferences were held on education, industrial voltage requirements, relays, statistical methods, machine tool and process drives, education, and on the standardization activities of the committee on air transportation. Symposiums on lighting and sound recording completed the technical program for which 78 technical papers and 24 conference papers were prepared and presented. The Transaction section of *Electrical Engineering* beginning with the January issue currently is being devoted to the publication of these papers. Also, many of the special addresses and informal conference presentations will be reflected in early issues of *Electrical Engineering*.

Analysis of Verified Registration at Recent Winter Conventions

District	1941*	1943	1944	1945	1946
New York (3).....	523..	569..	608..	704..	1,123
Middle Eastern (2).	946..	417..	474..	463..	645
North Eastern (1)..	276..	254..	301..	278..	474
Great Lakes (5)...	122..	97..	131..	153..	200
Southern (4)......	27..	22..	80..	40..	65
Canada (10)......	12..	25..	29..	41..	52
South West (7)....	2..	17..	21..	32..	38
North West (9)....	8..	6..	6..	3..	7
North Central (6).	12..	6..	4..	1..	7
Pacific (8)........	3..	6..	4..	3..	13
Totals..........	1,931..	1,419..	1,658..	1,718..	2,624

* Previous record registration; Philadelphia, Pa.

Two medal presentations were made. Presentation of The Edison Medal to Philip Sporn (F '30) vice-president and chief engineer, American Gas and Electric Service Corporation, New York, N. Y., took place at the general session on Wednesday, January 23, at which Doctor J. R. Dunning, director of the division of war research, Columbia University, and technical adviser to the Kellex Corporation, spoke on "Development of Atomic Energy." The jointly awarded Hoover Medal was given to W. H. Harrison (F '31) vice-president of the American Telephone and Telegraph Company, New York, N. Y., at an AIEE–IRE meeting held Wednesday evening. The featured address of that meeting by Major General Leslie R. Groves was "Some Electrical Engineering and General Aspects of the Atomic Bomb Project."

A dinner dance, held at the Hotel Plaza, and the women's luncheon, bridge, and fashion show at the Hotel Pierre, reappeared on the program after a three-year absence. As usual, success of the smoker held on Tuesday was assured before the convention opened, by which time all tickets had been sold. Inspection trips were made to the aircraft carrier *Franklin*, in the Brooklyn Navy Yard, to the Westinghouse Meter Works, Newark, N. J., to Waterside generating station of the Consolidated Edison Company, New York, N. Y., and to the Bell Telephone Laboratories at Murray Hill, N. J.

Many committee and subcommittee meetings and the customary meeting of the AIEE board of directors were held during convention week and are reported elsewhere in this issue.

Personnel of the committees which arranged convention activities follows:

Winter Convention Committee: C. S. Purnell, *Chairman*, J. L. Callahan, M. D. Hooven, R. A. Jones, A. E. Knowlton, J. H. Pilkington, J. J. Pilliod, C. C. Whipple.

Smoker: C. T. Hatcher, *Chairman*, W. J. Barrett, C. F. Bolles, A. J. Cooper, T. C. Duncan, H. E. Farrer,

Analysis of Registration at 1946 Winter Convention

Classification	Dist. 3	Dist. 1	Dist. 2	Dist. 4	Dist. 5	Dist. 6	Dist. 7	Dist. 8	Dist. 9	Dist. 10	Foreign	Totals
Members	838	384	506	53	163	6	32	12	6	40	3	2,043
Men guests	221	66	110	5	31	1	6		1	5	4	450
Women guests	41	20	27	7	6					7		108
Student members	16	4	2					1				23
	1,116	474	645	65	200	7	38	13	7	52	7	2,624

J. B. Harris, Jr., William Jordan, E. B. King, E. G. D. Patterson, D. M. Quick, W. H. Rodgers, H. B. Snow, D. W. Taylor, E. F. Thrall, W. R. Van Steenburgh.

Dinner-Dance: G. J. Lowell, *Chairman*, E. S. Banghart, J. M. Comly, J. G. Derse, E. T. Farish, H. E. Farrer, S. B. Graham, L. F. Hickernell, J. B. MacLean, J. P. Neubauer, Ernst Ohnell, H. C. Otten, E. C. Plant, P. W. Spence, W. H. Taubert.

Inspecton Trips: R. T. Oldfield, *Chairman*, P. H. Adams, E. F. DeTurk, H. E. Farrer, R. W. Gillette, R. K. Honaman, J. R. Kerner, H. H. Nance, W. A. Petrasek, R. M. Pease.

Ladies' Entertainment: Mrs. J. F. Fairman, *Chairman*, Mrs. T. F. Barton, Mrs. R. F. Brower, Mrs. C. W. Franklin, Mrs. R. A. Jones, Mrs. H. S. Osborne, Mrs. J. J. Pilliod, Mrs. C. S. Purnell, Mrs. D. A. Quarles, Mrs. G. S. Rose, Mrs. W. R. Smith, Mrs. G. Sutherland.

Theatre and Broadcast Tickets: H. H. Heins, *Chairman*, G. H. Campbell, G. J. Dyktor, W. Hayden, Jr., H. E. Murphy, T. J. Talley, 3rd.

Boundaries Between Physics and Engineering Discussed at Conference

In opening the conference on education during the winter convention, Professor H. W. Bibber (M '30) chairman of the AIEE committee on education, noted that the employment of physicists and electrical engineering graduates side by side in civilian war research agencies during the past five years had raised pertinent questions as to the boundaries between the work of the professional physicist and the graduate of an electrical engineering curriculum. Some observers, he pointed out, went further, as did an editorial writer in *Fortune* for November 1945 who wrote: "If basic scientists were able to perform important war engineering jobs that were beyond engineers, something is wrong somewhere."

He then stated that the object of the conference was to explore the situation before the important details were forgotten. He expressed the hope that as many facts and as much personal testimony as time permitted might be brought out, and indicated that the question as to what action should be taken in view of what had been revealed by the war would also be in order. He then promised participants anonymity in the reporting of the conference in print, so that no one would feel unduly restrained in the discussion.

Among the well-known physicists and electrical engineers who participated in the discussion were AIEE President W. E. Wickenden (F '39), Doctor L. A. Turner of the Radiation Laboratory at Massachusetts Institute of Technology; Doctor F. B. Jewett (HM '45), and Doctor W. L. Everitt (F '36).

IMPLICATIONS OF ENGINEER'S INFERIORITY DENIED

In summarizing the discussion, it was agreed by all participants that the implied inferiority of the engineer to the physicist did not in fact exist to any appreciable degree, if one compared men of equal intellectual caliber who had received the same number of years of academic training, and whose research experience had been equally broad.

It was suggested that comparisons had been made sometimes between doctors of philosophy in physics with some years of research experience in which they were free to do what they liked, and electrical engineering graduates with only four years of college work whose minds had been routinized by years of industrial experience that was prescribed and restricted, even if it had been called research.

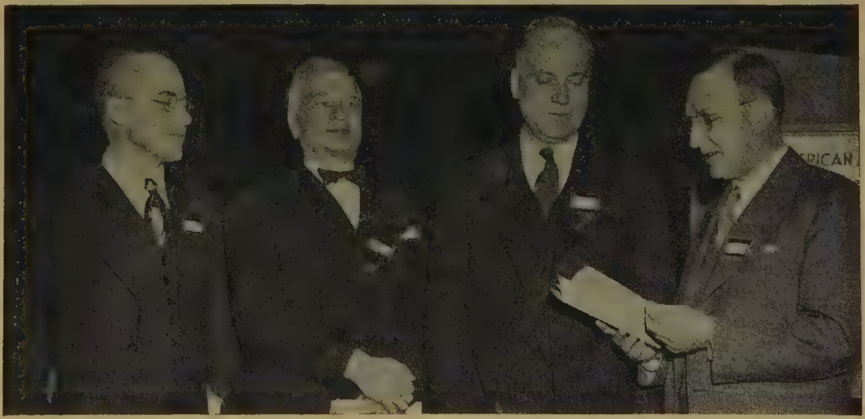
The next point made by several speakers was the fact that the physicist in the war research agencies was using the full range of his talents, whereas the engineer was not able to utilize his cost analysis training, since cost was never a consideration in military devices.

There has never been any question about the contributions of engineers to the design of devices for rapid production. This was as true in the research agencies as in industry. A kind of originality and inventiveness is needed here, but it is not as impressive to the outsider as the original conception of the device. From a practical military standpoint a novel device is of no use unless thousands can be produced quickly.

Certain jobs in war work called for a hybrid type of preparation, in part pure physics and in part engineering. There was some agreement that the physicists were able to pick up the engineering methods that were needed more rapidly than engineers brought into the laboratories from industry could acquire the methods of advanced mathematical analysis and the knowledge of physical theory in fields remote from electrical engineering. The physicists' thinking was not stereotyped and they often came up with unorthodox solutions to problems which led to notable inventions.

In defense of the reputation of the engineers it was pointed out that in setting up the National Defense Research Council and Office of Scientific Research and Development agencies, a great many physicists were put in key positions, and these men called on others in the physics field whom they knew and in whom they had confidence to set up laboratories and assemble staffs. The chain once being started propagated itself. Furthermore, many of the gifted development engineers were in important industrial jobs from which it was inadvisable to move them. Thus, it was asserted, there had been no valid opportunity for comparison, and in any case no direct comparison was possible or significant to engineering education.

Caution in making too many changes in engineering curricula was advised because the physicists' accomplishments in development engineering may have been due to their newness to engineering. If they had continued in engineering work for several



T. G. LeClair (F '40) Commonwealth Edison Company, Chicago, Ill.; S. H. Mortensen (F '20) Allis-Chalmers Manufacturing Company, Milwaukee, Wis.; C. M. Laffoon (M '39) Westinghouse Electric Corporation, East Pittsburgh, Pa.; M. W. Smith (F '42) Westinghouse Electric Corporation, Pittsburgh, Pa. (left to right)

more years their level of accomplishment might have become that of their peers among the professional engineers in industry. Perhaps the broad knowledge which comes from teaching advanced physics in universities and the zest for work which comes from independent research fit the scientists for early successes in engineering development. It may be that their ignorance of the accepted traditions current in the branch of engineering into which they are plunged is an advantage, in that they are not held down initially by any wrong ideas which may have been hallowed into cant by the passage of years. If these things were true then the engineering teachers from colleges who went into the war research agencies may have done as much outstanding work as their physicist coworkers. But the fact seems to be that most mature engineering teachers were asked to stay on in their institutions to teach Army and Navy personnel sent to them, so that little information can be secured on this point.

CRITICAL EXAMINATION OF SCIENCE CONTENT OF ENGINEERING CURRICULA DESIRABLE

Speakers recognized the change that has taken place in the past 40 years in engineering curricula starting from a condition of many hours training in high level skills and coming down to the present with a much lessened content of drawing and shop work, and increased work in fundamental science and associated mathematics. The key question asked was: has each school now the absolute minimum number of hours devoted to these subjects appropriate to the type of engineer they have chosen to educate. It was evident that considerable variety in engineering curricula is desirable, and while a few schools may drop shop work entirely, not all schools would wish to, nor should they do so in the interests of the country.

Application courses took the beating which has been common at engineering education meetings in recent years, along with "informational," "handbook," and "sightseeing" courses. An increase in basic scientific content and more emphasis on possible methods of solving problems rather than the detailed solution of practical type problems were advocated. Fundamental courses in other fields were thought desirable, for example, instead of heat engines and boilers, a course in thermodynamics and heat transfer. Most speakers agreed that industry should provide the application aspect of an engineer's training, not the schools.

Ascribing part of the college problem to the teaching staff, rather than the curriculum, several discussers recalled that the higher salaries in industry had drawn some of the most vigorous and stimulating teachers of engineering graduate subjects and research into industry. Perhaps fewer gifted physicists had been attracted to industry. This intellectual impoverishment of the colleges' engineering faculties is a real problem for industry and the national defense, as the goose that lays the golden eggs, is being killed.

AIEE President W. E. Wickenden (F '39) Case School of Applied Science, Cleveland Ohio, presents the Edison Medal to Philip Sporn (F '30) American Gas and Electric Service Corporation, New York, N. Y. Left to right are J. C. Parker (F '12) Consolidated Edison Company of New York (N. Y.), Inc., eulogist; Mr. Wickenden; Mr. Sporn; and A. E. Knowlton (F '30) *Electrical World*, New York, N. Y., member of the Edison Medal Committee

NEW FRONTIERS IN PUBLICATION OF PAPERS

The new frontiers between electrical engineering and physics in the field of publication of papers were reported to be still fluid, but not confused or undesirably competitive. The field ranged from pure physics at the center, out, as it were, along the spokes of a wheel toward the periphery of engineering application. Before reaching the engineering journals there was a region of emerging technology as differentiated from physics in which a constructive publication service to the engineering fields could be rendered. Particularly if the publications in the applied physics field endeavored to fill gaps not covered by any existing publication, could they render a constructive service.

Philip Sporn Receives Edison Medal

The Edison Medal, highest honor of the AIEE, was awarded for 1945 to Philip Sporn (F '30) executive vice-president, American Gas and Electric Service Corporation, New York, N. Y., "for his contributions to the art of economical and dependable power generation and transmission." The award was made on January 23, 1946, at a general session of the AIEE winter convention, New York, N. Y.

Prior to the presentation A. E. Knowlton (F '30) acting for R. E. Doherty (F '39) chairman of the Edison Medal committee, outlined the history of the medal which was established by a group of friends and associates of Thomas A. Edison to serve "as an honorable incentive to scientists, engineers, and artisans to maintain for their works the high standard of accomplishment" set by Edison himself. Funds for a memorial to the great inventer had been raised from many contributors and, following a period of several years of uncertainty with regard to the best form the memorial should take, the plan of awarding an annual gold medal was adopted in 1908. Since 1909 it has been awarded every year but two by a committee of the AIEE to a resident of the United States or Canada "for meritorious achievement in electrical science, electrical engineering, or the electrical arts."

AIEE Past President John C. Parker (F '12), in an address directed to Mr. Sporn, described the medalist's qualifications for the award. He declared that Mr. Sporn's engineering accomplishments were so many that it would be difficult to select the most meritorious and so it was necessary to substitute an over-all appraisal of Mr. Sporn's work, a principal factor in the development of the power system.

Doctor Parker emphasized the fact, however, that it was not Mr. Sporn's objective achievements that were being signalized by the award but rather his method of approach to problems and their successful solution. "In all your work," he said, "you have shown imagination, systematic logic, and the courage to bring the results of research through the successful processes of design and development into physical being."

In his response after President W. E. Wickenden had presented the medal and certificate, Mr. Sporn reviewed some developments in power transmission and generation, the field in which Edison himself was known best. He remarked that, although it is not known generally, Edison was concerned greatly with the dependability and economy of his power system and that no modern system can have any practical value without these attributes

Edison Medalists

1909	Elihu Thomson	1922	Robert A. Millikan	1934	Willis R. Whitney
1910	Frank J. Sprague	1923	John W. Lieb	1935	Lewis B. Stillwell
1911	George Westinghouse	1924	John W. Howell	1936	Alex Dow
1912	William Stanley	1925	Harris J. Ryan	1937	Gano Dunn
1913	Charles F. Brush	1927	William D. Coolidge	1938	Dugald C. Jackson
1914	Alexander Graham Bell	1928	Frank B. Jewett	1939	Philip Torchio
1916	Nikola Tesla	1929	Charles F. Scott	1940	George A. Campbell
1917	John J. Carty	1930	Frank Conrad	1941	John B. Whitehead
1918	Benjamin G. Lamme	1931	E. W. Rice, Jr.	1942	Edwin H. Armstrong
1919	W. L. R. Emmet	1932	Bancroft Gherardi	1943	Vannevar Bush
1920	Michael I. Pupin	1933	Arthur E. Kennelly	1944	E. F. W. Alexanderson
1921	Cummings C. Chesney			1945	Philip Sporn

a fact which must be considered in our expanding industrial system. This problem, quite independent of that of atomic energy which, Mr. Sporn pointed out, must prove its worth in the electric power field, will be of major interest in the postwar world.

Essentially full text of Mr. Sporn's address appears elsewhere in this issue.

W. H. Harrison Receives Hoover Medal

Continuing the practice of recent years, a joint evening session was held during the AIEE winter convention with the Institute of Radio Engineers which was meeting concurrently in New York. During the first portion of the program, presided over by AIEE President William E. Wickenden, the Hoover Medal was presented to AIEE Past President William Henry Harrison (F '31) executive vice-president in charge of operation and engineering, American Telephone and Telegraph Company, New York, N. Y., and formerly major general, Army of the United States. The second portion of the program, under the chairmanship of IRE President W. L. Everitt (F '36), was devoted to an address, "Some Electrical Engineering and General Aspects of the Atomic Bomb Project," delivered by Major General Leslie R. Groves.

The Hoover Medal is a joint award of the AIEE, the American Society of Civil Engineers, the American Society of Mechanical Engineers, and the American Institute of Mining and Metallurgical Engineers, to "a fellow engineer for distinguished public service." As recalled by Stephen F. Voorhees, ASME representative on the Hoover Medal Board of Award, in his presentation address, General Harrison is the eighth recipient of the medal, the first award being made in 1930 to Herbert Hoover. Mr. Voorhees described the qualifications of the medalist who is being honored, as were his predecessors, not only for his professional services to society, but for other services based upon broad understanding of human needs. He stressed the fact that not only has General Harrison contributed much professionally to the communications industry, but he also has found time to undertake many public services. In recognition of his contributions, General Harrison received the Distinguished Service Medal, the Government's highest award for service off the battlefield.

In his response General Harrison attributed his achievements to the opportunities existent in the United States and to his professional environment. In regard to his wartime experience he paid tribute to those engaged both in combat and industrial duty, predicting that the war-stimulated advances in science and in industry "herald a future so plentiful of goods and of services as to provide for all peoples a better way of life." In his acceptance speech General Harrison confessed that much as he treasured the award his greatest compensation is that satisfaction which a man has when he believes that he has done his duty.

W. H. Harrison (F '31) American Telephone and Telegraph Company, New York, N. Y. (left) receives the Hoover Medal from S. F. Voorhees, representative of The American Institute of Mechanical Engineers on the Hoover Medal Board of Award. Presentation was made at a joint meeting of the AIEE with the Institute of Radio Engineers during the recent AIEE winter convention

Institute Activities Discussed at Conference

Sponsored by the Institute's committee on planning and co-ordination, a full afternoon conference session during the recent winter convention was devoted to a discussion of Institute activities and relationships with other professional societies. This was the first of several membership forums planned by the committee for the purpose of extending the discussion of these topics, in furtherance of its current special study, as previously reported in *Electrical Engineering*.

President Wickenden, in outlining the necessity and desirability of having such discussion meetings, stated that his "great concern is that the Institute shall be able to respond quickly to fundamental changes in art, science, industry, and the concerns of its members," and be able to "provide such a complete and satisfactory service in these fields that no group will be tempted to step outside the fold and organize separate societies, thus contributing to the progressive fragmentation of the profession." He emphasized also the desirability of "improving the prestige of the engineering profession by having it speak as one voice instead of a babble of 90 voices which very largely cancel each other out to the extent that the engineering profession cannot be influential in public and essentially over-all professional matters."

The first part of the conference was devoted to an informal discussion of the Institute's technical activities sponsored by the technical activities subcommittee. Various suggestions were made for organizational or procedural improvements, including a detailed suggestion for decentralization and the establishment of semiautonomous technical divisions the better to foster and correlate technical activities in related subject fields.

The second part of the conference was given over to the discussion of a preliminary report presented by the professional activities subcommittee. This report, reflecting the subcommittee's initial attack on its particular problem, outlined four plans contemplating the more or less complete reorganization of the engineering profession. "Plan A" proposes the consolidation of the various technical and professional organizations in the electrical engineering field into a single electrical engineering organization. "Plan B" proposes continuation of technical activities as at present under the various engineering professional and technical societies, supplemented by a parallel organization which would devote itself to the professional, civic, and other questions of more or less common interest to engineers. "Plan C" proposes the federation of all existing engineering societies, for the correlation of technical activities on the one hand, and the correlation of professional, civic, and other interests on the other hand. "Plan D" proposes the establishment of an entirely new engineering society which would absorb and integrate all activities of all existing engineering and technical societies.

Among the additional topics brought up in the ensuing general discussion were: the professional problems involved in the present industrial trend toward complete unionization, and collective bargaining; the need for a careful study and evaluation of basic aims and objectives. Doctor Funk, AIEE past president and currently acting chairman of the Engineers Joint Council committee on organization of the engineering profession, stated that the work of the professional activities subcommittee and the discussions of the conference session paralleled the work of his committee. Such discussions "can be helpful if the AIEE keeps an open mind, and harmful if the members make any quick decision that some one of the particular plans so far discussed must be adopted. The different national societies have different points of view," he said. In commenting upon the frequently expressed desire to have a society "like the American Medical Association," Doctor Funk pointed out that, quite unlike the engineer, the doctor, regardless of professional specialty practice, always has the same individual and direct doctor-to-patient contact and relationship.

According to the present plans of the committee on planning and co-ordination, the essential substance of the report of its committee on professional activities, together with the essence of the member discussions at the winter convention conference, are scheduled for publication in the April issue of *Electrical Engineering* as a preliminary to further discussion of the matter at the summer convention conference of officers, delegates, and members. April publication will place the matter before the entire membership, and make possible a full discussion of the situation by the various Sections as a basis for orientation of their delegates to the summer convention conference It is expected that the planning and co-ordination committee will be in direct contact with Section officers in the furtherance of such plans for general discussion.

Committees and Subcommittees Meet During Winter Convention

Many AIEE committees and subcommittees held meetings in New York, N. Y., during the week of the 1946 winter convention, in accordance with the usual custom. Matters that are of interest to the membership as obtained from the reports of the committee chairmen are outlined in the following paragraphs.

EDUCATION

Inclusion of certain educational activities as desirable parts of local Section programs was discussed, leading to the establishment of the committee's views that local Sections should seek to stimulate the offering of courses desired by their members in schools and colleges in the Section territory. If such institutions are not available then the local Section should organize them on its own initiative using available meeting space. It was recommended that any AIEE sponsored courses always should carry a substantial fee not only to cover expenses but to stimulate attendance. Educational activity at this time was held particularly appropriate because of the return of veterans and the changes in the work of many engineers. The use of motion-picture films as teaching aids in electrical engineering was considered, and the work of a subcommittee, as done several years ago, was reviewed. It was pointed out that the military services have prepared films for instructional purposes, and that many soon may be made available. Also, manufacturers may contemplate postwar visual education programs, and it is desirable that they should know of the committee's interest in such films. Suggested specific uses for films included animated cartoons for particular devices and films as a substitute for inspection trips, for orientation to show kinds of engineering work, and to indicate professional activities. The possible need of support from educational foundations in producing some films and the need of better arrangements for securing films were discussed.

A new topic discussed was the standardization of laboratory equipment, which was held to offer the possibility of lower prices. The advantages and disadvantages of each school laboratory being a law unto itself were discussed, but in the end it was voted that a subcommittee be appointed to investigate possible standardization.

STUDENT BRANCHES

The most important matter considered at the meeting of the committee on Student Branches was the decision to permit joint Student Branches of AIEE and the Institute of Radio Engineers. It was the recommendation of the committee that the AIEE board of directors be requested to take appropriate action in co-operation with the proper representatives of IRE and to arrange at the earliest opportunity all details essential to the successful operation of the joint branches. Thus Student members in either AIEE or IRE automatically share equal rights in joint Student Branches in addition to the advantages offered by their particular society, and are eligible to transfer to a regular membership grade in either participating society without entrance fee. Hope was expressed that such joint Student Branches eventually will include student members of other societies of similar type and policy.

A decision also was reached to proceed with District student conferences which were interrupted during the war.

MEMBERSHIP

The AIEE membership committee was well represented at the winter convention, members from many Districts being present. The meeting of the committee was enthusiastic with the thought remaining paramount that the committee should continue to be alert to the possibilities of interesting qualified persons in the advantages of Institute membership, and in being helpful to those who desire assistance in filing their applications. There appeared to be no need to change the present policy of the committee at this time.

It is the desire of the membership committee that the present methods of acquainting executives with the aims and activities of the Institute be continued. No change in the procedures being followed in this respect seems to be warranted. The committee has found that its publications for aiding membership activities have been effective and should be continued in their present form. However, another aid in the form of a handy booklet was approved as an additional medium of distributing the information considered pertinent to a person giving thought to applying for membership.

The membership as of January 18, 1946, was 24,309. Approximately 500 applications for membership are posted or are to be posted, and 263 were awaiting final action by the board of directors. Thus, the membership of the Institute is expected to pass 25,000 at an early date—a marked increase since April 30, 1944, when the membership was 21,407. The delinquents are the lowest by a large margin for a great number of years.

Student members totaling 861 have been invited, as is the custom in January of each year, to consider applying for membership in the Associate grade.

TELEMETERING

At a meeting of the AIEE joint subcommittee on telemetering on January 23, the 1941 "AIEE Report on Telemetering, Supervisory Control, and Associated Circuits" was reviewed in preparation for revision. New questionnaires for submission to manufacturers of such equipment were planned, and the co-operation of AIEE members in submitting names and addresses of manufacturers who recently have entered the telemetering field with systems employing electric translating means and suggestions for changes or additions to the earlier report was requested.

It was decided that the 1946 revised report should include at least a brief description of the various physical types of carrier current channels suitable for telemetering and supervisory control, and possibly of the commercially available types of automatic load frequency control, using similar channels, often in combination with telemetering.

LAND TRANSPORTATION

At a meeting of the AIEE committee on land transportation during the winter convention, two subcommittees were appointed, one to revise the Standards for railway control apparatus, ASA C-48, and the other to prepare a questionnaire to be sent to all railroads so that a complete compilation of information on American steam road electrifications and a similar compilation on foreign roads similar to those produced in National Electric Light Association reports of some ten years ago can be made.

Consideration was given to a suggestion that there is a need for standards for electric apparatus used on military vehicles and for other military apparatus.

METALLIC RECTIFIERS

At a meeting of the AIEE subcommittee on metallic rectifiers on January 25, plans were made for the completion of standards on nomenclature including symbols and circuits and of test codes for metallic rectifiers. The subcommittee agreed to meet as a body at least four times during the year, timing the meetings with AIEE District meetings.

INDUSTRIAL CONTROL DEVICES

A new AIEE committee, that on industrial control devices, held a meeting during the winter convention with the objective of determining the place and scope of the committee within the Institute. A subcommittee on electronic industrial control devices has been established to work in co-ordination with the AIEE committee on electronics, as well as to give full recognition to other organizations which also are working on application of electronics to industrial purposes.

Other plans made by the committee include liaison with the American Society for Testing Materials, which is testing contact materials and shapes, consideration of a bibliography on industrial electrical control, and the desirability of a test code for control devices.

G. A. Burnham (A '03) Allis-Chalmers Manufacturing Company, Boston, Mass.; J. B. MacNeil (F '42) Westinghouse Electric Corporation, East Pittsburgh, Pa.; H. W. Collins (M '42) Detroit Edison Company, Detroit, Mich. (left to right)

PROTECTIVE DEVICES

A meeting of the AIEE subcommittee on fault limiting devices of the committee on protective devices, formerly known as the subcommittee on fault current limiting devices, was held on January 23 under the chairmanship of F. R. Longley (M '42). The name was changed to indicate the full scope of the work of the subcommittee which deals with devices that limit either current or voltage or both under fault conditions.

A new working group was formed to prepare a bibliography concerning system grounding. Progress also was reported on the revision of proposed standards for neutral grounding devices which were prepared for trial use.

The AIEE subject committee on present day grounding practices, which met on January 23, has prepared a questionnaire to be submitted to the principal power companies of the United States and Canada.

POWER GENERATION

At a meeting of the AIEE committee on power generation on January 24, plans were made to sponsor sessions at the forthcoming 1946 summer convention on hydroelectric systems and excitation systems, and at the 1947 winter convention on hydroelectric systems and interconnected electric systems. A long range program has been undertaken by the committee on the subject of hydroelectric systems which in the past has received rather scant attention.

INSTRUMENT TRANSFORMERS

A joint meeting of the subcommittee on instrument transformers of the AIEE committee on instruments and measurements, the test code subcommittee for instrument transformers, ASA transformer Standard C-57, and the AIEE relay subcommittee working group on instrument transformer standards, was held on January 24, primarily to discuss the form of the instrument transformer test code. A proposed form known as the "short form" was accepted.

INSULATION RESISTANCE

At a meeting of the AIEE subcommittee on insulation resistance on January 23, progress was reported on work which is directed toward setting up standards for silicone insulation. It was recommended tentatively that these materials be known as class H insulations and that their maximum hot spot temperature be set at 180 degrees centigrade. The subcommittee also discussed minimum insulation resistance for d-c machines and it is expected that agreement can be reached on proper limits during the coming year.

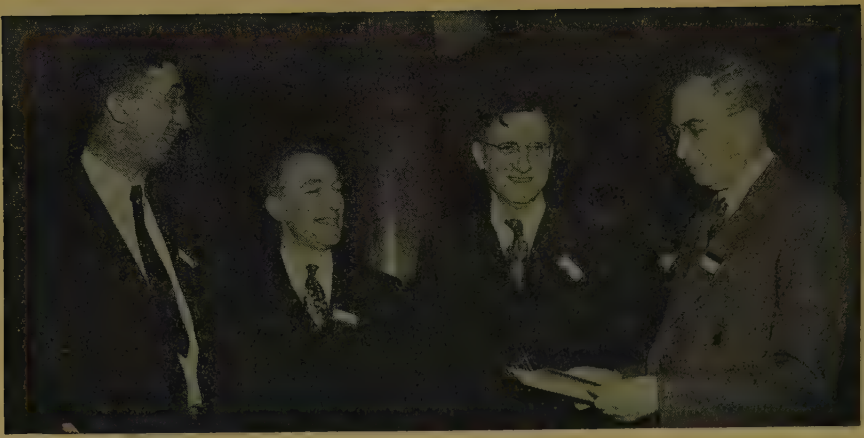
ELECTROCHEMISTRY AND ELECTROMETALLURGY

At a meeting of the AIEE committee on electrochemistry and electrometallurgy on January 24 there was considerable discussion of the point raised by a number of industrial members of the Institute that AIEE activities and publications do not offer much material of benefit to them. The committee went on record as recommending that an AIEE committee be organized to foster the preparation of papers of the industrial and economic type and that such papers be published in *Electrical Engineering* in a section separated from the highly technical papers which now comprise most of the editorial content.

SAFETY

The committee on safety, L. F. Adams (F '42) chairman, met on January 22. The members were enthusiastic in their support of the program proposed for the committee's activities for the current year. It is expected that the committee will take active steps to assist colleges to improve their engineering courses by inclusion of adequate instruction in the need for and methods of incorporating electrical safety in equipment design and in manufacturing processes.

The committee also expects to continue its present stimulation of interest in active study of electrical hazards, and methods of avoiding or safeguarding against them.



A. W. Hill (M '41) Westinghouse Electric Corporation, East Pittsburgh, Pa.; W. R. Brownlee (M '38) Commonwealth and Southern Corporation, Jackson, Mich.; H. B. Wolf (M '37) Duke Power Company, Charlotte, N. C.; M. H. Hobbs (M '37) Westinghouse Electric Corporation, East Pittsburgh, Pa. (left to right)

Papers on these subjects are contemplated for future meetings.

CARBON BRUSHES

The joint subcommittee on carbon brushes appointed by the AIEE committees on electric machinery and air transportation met to continue preparation of a test code on carbon brushes. The purpose and scope of the code was discussed and preliminary agreement obtained on the outline of contents. Tests under both high altitude and sea level conditions will be included for brushes ranging in size from miniature to those for large machines. Writing of the component parts of the code will begin at once by individuals and groups assigned by Doctor V. P. Hessler (F '43). These will be co-ordinated into a preliminary code. The eventual code will make it possible for manufacturers to publish properties of brushes in accordance with recognized AIEE tests and users will be able to understand the source of published data and to make duplicate tests.

ELECTRONICS

In the absence of the chairman and vice-chairman, W. C. White (M '30) conducted the meeting of the AIEE committee on electronics on January 24.

Doctor C. H. Willis (F '42) presented the "Proposed Standards for Electronic Power Converters" on behalf of his subcommittee. These represented over 2,000 man-hours of work by this group. After some discussion, they were approved subject to certain minor changes outlined by Doctor Willis. They will then be sent to the Standards committee. It was also recommended that they be published as a set of proposed standards.

A report of the electronic power conversion subcommittee on inductive co-ordination aspects of rectifier installations was presented by H. R. Huntley (M '29). This was acted upon similarly.

A report of the subcommittee on nomenclature, definitions, letter and graphical symbols was presented by its chairman, R. S. Burnap (M '29). This covered a considerable number of definitions of various kinds of electron tubes and electronic devices. These, in general, are items not covered by IRE definitions or terms not included by the report of Doctor Willis' subcommittee. With the exception of a certain few definitions on which postponement of action was requested by Mr. Burnap, the report was approved for submission to the Standards committee.

A written or verbal report was made by the majority of the committee's 12 subcommittees.

The chief objective for the present year is an increased activity in promoting interest among Institute members in electronic devices in industry, particularly in certain specialized fields where little has been done by the AIEE.

APPLICATIONS OF ELECTRICITY TO THERAPEUTICS

A meeting of the committee on the applications of electricity to therapeutics was held on January 23. The following problems were discussed:

1. The possible danger to operators who are handling high frequency heating and soldering equipment. It was the general opinion of the committee that workers could be shielded from high frequency fields by interposing a metal barrier between the operator and the source of energy. There was no information as to the amount of heat to which a human may be subjected without injury.

2. The amount of ultraviolet radiation produced by various types of lamps such as sun lamps, sterilizing lamps, and special lamps. The lamp manufacturers expressed their willingness to furnish equipment for a scientific study of the amount of ultraviolet radiation of various wave lengths that are produced by these lamps.

BUSHINGS AND POTHEADS

Culminating discussions and studies that have continued over a period of several years, the subcommittee on bushings and potheads, of the AIEE Standards committee, decided that dielectric test values for potheads should be essentially the same as for apparatus bushings. One school of thought consistently has held out for the use of higher dielectric test values for potheads and for bushings, but field tests and observations carried out over an extended period of time under the surveyance of the subcommittee failed to reveal any justification. Hence, the committee's decision, which is one of far-reaching importance.

SECTIONS

A meeting of the AIEE Sections committee was held on January 22, 1946, with an attendance of 50, at which the results of the conferences on Section operation and management held at the District meetings were discussed. It was the consensus of the meeting that these conferences were very helpful to the Section officers.

The meeting was opened with a short talk by Dr. Wickenden who pointed out that the American Institute of Electrical Engineers is the largest and most rapidly growing of the national societies. He emphasized the importance of meeting the challenge of revolutionary changes in the industry, adding that the local Sections are responding quickly as a result of their being closer to the problems. He then stated that efforts are being directed to make the national organization of the Institute similarly responsive.

Plans were discussed for the delegates meetings to be held at the summer convention in Detroit, Mich. These plans include three conferences on Section operation and management following the pattern used in St. Louis, Missouri, in 1944. These conferences will be entirely informal. The annual meeting of Section delegates will be held after the conferences. The program at this meeting will be devoted strictly to important phases of Section operation and management. Special conferences were also planned to be held later in the summer convention week on the organization and operation of local engineering councils and on student activities.

The development of technical groups was reviewed. The number of such groups in active operation increased from 27 at the end of the 1943–1944 operating year to 51 at the end of the 1944–1945 season, and 23 new groups are reported as having been formed during this year. Many additional groups are being organized as the value of these groups, operated within the Section, is becoming more generally recognized.

The operation of Subsections was discussed as a valuable means of accomplishing the objectives of the Institute by providing additional meeting places at which papers on electrical engineering subjects may be presented and discussed. Six additional Subsections started to function in the present operating year, making a total at present of 21 active Subsections. Six projects for new Subsections were also reported.

The present arrangements for financing the Sections were thoroughly discussed. A plan for increased appropriations is to be presented by the Sections committee for approval.

There was active discussion on the program of the Sections committee for promoting the organization of local councils of engineering and technical societies where they do not exist and encouraging the AIEE Sections to take an active part in the operation of the councils that now exist.

Announcement was made that the Institute pamphlet on prize papers was being rewritten by a special committee. It was the unanimous opinion of those present that any revision of this pamphlet should make adequate provision for Section prize paper contests.

I. M. Stein (F '39) chairman of the AIEE committee on collective bargaining and related matters, reviewed the report of his committee and requested all Section representatives to have individual Section members write to the committee, giving their personal reactions to this report which was published in the July 1945 issue of *Electrical Engineering*.

Conference on Air Transportation

The conference on air transportation sponsored by the AIEE committee on air transportation during the winter convention was held to review the work of the committee on test codes and Standards and to discuss future activities. Following an outline of the procedure followed in the development of Standards and test codes by J. R. North (F '41), the chairmen of active subcommittees presented reports covering their work. It was decided that recommendations would be sought from the aircraft industry and military services for changes in AIEE publication 700, "Preliminary Report on Standard D-C Voltages for Aircraft." This report was issued in March 1945 for a one-year trial period, and action leading to a final Standard is desirable.

A decision was reached to appoint a subcommittee for investigation of safe practices in electric equipment because it was pointed out that electric equipment was blamed for fires and other failures on aircraft, often without any adequate reason. The subcommittee is to make recommendations as to whether the air transportation committee should undertake the problem of making recommendations leading to maximum safety in the use of aircraft electric equipment.

Conference on Statistical Methods

A subcommittee on statistical methods of the AIEE Standards committee sponsored a conference during the winter convention in order to give the membership information about the work which the subcommittee has done during the last year and to aid in planning future activities.

Several speakers emphasized the importance of selling statistical quality control to management. Need was seen for more papers on this phase of the subject at Institute meetings and for interpretive articles to bridge the gap between the theoretical worker and the quality control engineer. Articles of a more advanced type to supplement the educational articles currently appearing in *Electrical Engineering* were advocated.

Informal Conference on Electronics

In keeping with the general theme of "new frontiers" adopted for the winter convention, the electronics committee chose the subject "New Industrial Uses of Electronics Resulting From Wartime Developments" for an informal technical conference.

An analysis of the approximately 250 persons who attended showed the following representation:

Manufacturers of electronic equipment	28 per cent
Other manufacturers	36 per cent
Government laboratories and departments	15 per cent
Educational institutions	10 per cent
Public utilities	8 per cent
Press, consulting engineers and miscellaneous	3 per cent

Practically all the technical advances described resulted from wartime developments in radar. Two speakers described the characteristics or applications of hydrogen-content thyratrons, which have been found suited for operation at frequencies of several thousand cycles per second or where a very high ratio of peak-to-average plate current is required. Their use for pulse testing of windings and generation of frequencies in the audio range was described.

Another speaker discussed magnetrons for the production of frequencies of hundreds or thousands of megacycles per second, pointing out that tubes of this type were suited particularly for sources of power for dielectric heating, because of their good efficiency and circuit simplicity.

Other speakers described recent advances in high-frequency heating and a wide range of new applications. Important features mentioned were automatic tuning of heaters with varying loads, development of specially shaped electrodes for specific applications, and the automatic regulation of output to maintain uniform heating of any one object in a production line even though the number of objects to be heated varied.

It was indicated that much study is being given to heat transfer within the object being heated and that improved knowledge has reduced the amount of application engineering time required on new installations.

Conference on Slow-Acting Relays

A conference under the chairmanship of H. M. Turner (F '44) was arranged by the AIEE communication committee during the winter convention in order to explore the interest in the subject of slow-acting relays as an aid in planning a session on the subject for a future convention.

Slow-acting relays have many uses but their widest application is in automatic telephone systems where they are an essential element. Despite their importance, however, relatively little detailed or even general information is available in the literature. To provide a proper background for general discussion, the following topics were outlined briefly by leaders: Historical aspects, underlying electromagnetic concepts, operational features, and uses of telephone relays for power purposes.

The committee has invited suggestions from all interested members regarding the desirability of holding a session on the subject at the 1947 winter convention, phases of the subject of most interest, and the names of possible authors.

Conference on Machine Tool and Process Drives

A conference on machine tool and process drives was held during the AIEE winter convention under the direction of a newly formed subcommittee with Philip Bliss (A '43) as chairman. The reports submitted by the chairman pointed out that this subcommittee was formed at the beginning of the 1945–46 Institute year for the purpose of developing a report and series of papers covering the modern trend in machine drives, with special emphasis on the newer forms of drives and special controls. One of the major functions of this committee will be to stimulate interest in this subject and bring the user and electrical manufacturer closer together, to their mutual benefit.

Manufacturers frequently are criticized for the design, wiring, and construction practices, especially with regard to maintenance accessibility and operating environment. Machines have been made on which it is practically impossible to perform maintenance and repair work. Frequently the criticism is deserved, but often the user must share the blame for lack of information for specifications. However, closer contact and co-operation between manufacturer and user should prevent much trouble with equipment, unsuitable for the application.

Present methods of installation of motors, control, and accessories in machine tools and other production equipment were criticized as contributing to excessive cost of maintenance. The trend toward enclosing all equipment within compartments to streamline appearance, often results in placing the equipment in inaccessible locations and in locations not satisfactory from an operating standpoint. The automobile industry was reported to have prepared a new standard for the selection and installation of electric equipment which has been placed in the hands of the National Machine Tool Builders Association.

Industrial Voltage Requirements Discussed at Conference Session

Continuing the work begun last year, the AIEE committee on industrial power applications conducted a conference at the winter convention on industrial voltage requirements. As the basis for discussion a preliminary report prepared by the subcommittee on industrial voltage requirements was presented by John Grotzinger

(M '44). The report outlined the effects of voltage variation from various types of electric equipment used in industry and set up permissible system voltage spreads based on a poll of industrial electrical engineers.

In a subsequent discussion of transformer taps and ratios and their bearing on industrial voltage requirements, presented by W. H. Dickinson (M '43) the apparent discrepancy between the voltage zones and the present range of standard taps was pointed out, as was the lack of sufficient information regarding voltage conditions of industrial consumers. It was suggested that a survey be made to determine such voltage conditions to serve as a basis for making an intelligent decision as to what action, if any, should be taken to secure better results from transformers having standard taps and ratios.

R. C. R. Schulze (M '31) discussed some of the difficulties which utilities encounter in trying to provide a power supply that is satisfactory from the standpoints of voltage level and spread. Surveys by industrial engineers and utilities it was said, should indicate the divergence of voltage conditions from ideal and would permit arriving at the best solution for both.

In discussion it was suggested that AIEE recommendations be permissive rather than mandatory A proposal was made by H. P. Seelye (F '43) representing the Edison Electric Institute–National Electrical Manufacturers Association group on preferred voltage ratings, that the AIEE industrial power application group co-operate with the EEI–NEMA group before issuing final recommendations. Another discusser expressed the need for co-ordination between designers of lamps and other types of electric equipment because the present ratings of 120 volts for lamps and 440 volts for motors are out of line. Others expressed the belief that terms regarding voltage ratings should be more explicit.

Further consideration of the subject of voltage requirements was proposed for the forthcoming summer convention.

Lamme Medal to D. C. Prince

The award of the AIEE Lamme Medal for 1945 has been made to David Chandler Prince, vice-president of the general engineering and consulting laboratory of the General Electric Company, Schenectady, N. Y., and past president of AIEE "for his distinguished work in the development of high voltage switching equipment and electronic converters."

The AIEE Lamme Medal, which is an annual award to an engineer "who has shown meritorious achievement in the development of electrical apparatus or machinery," was established through a bequest of the late Benjamin G. Lamme, chief engineer of the Westinghouse Electric Corporation. Disposal of the Medal is decided by an AIEE committee organized for that purpose. The first award was made in 1928. A biographical sketch of Doctor Prince appears on page 130 of this issue.

Future AIEE Meetings

South West District Meeting
San Antonio, Tex., April 16–18, 1946

North Eastern District Meeting
Buffalo, N. Y., April 24–26, 1946

Southern District Meeting
Asheville, N. C., May 14–16, 1946

Summer Convention
Detroit, Mich., June 24–28, 1946

Pacific Coast Convention
Seattle, Wash., in week of August 26–30, 1946

Great Lakes District Meeting
Fort Wayne, Ind., September 25–27, 1946

SECTION • • • • •

Toronto Section Forms Communications Group

As the culmination of many suggestions made by members of the AIEE Toronto Section, a communications technical group was formed by that Section late in the autumn of 1945. The formation of such an organization provides an opportunity for the presentation of communication papers and their discussion in technical detail.

The first meeting of the new group was held in the University of Toronto, Ontario, Canada, January 18, 1946, at which L. C. Ratcliffe (A '44) toll and transmission engineer, plant engineering division, Bell Telephone Company of Canada, presented a paper entitled "A 12-Channel Carrier Telephone System for Toll Cables." About 75 persons attended of whom 22 were members. Nineteen of the 53 nonmembers present requested application forms for membership in the Institute.

ABSTRACTS • • • •

TECHNICAL PAPERS previewed in this section will be presented at the AIEE South West District meeting, San Antonio, Tex., April 16–18, 1946, and will be distributed in advance pamphlet form as soon as they become available. Copies may be obtained by mail from the AIEE order department, 33 West 39th Street, New York 18, N. Y., at prices indicated with the abstract; or at five cents less per copy if purchased at the meeting registration desk.

Mail orders will be filled
AS PAMPHLETS BECOME AVAILABLE

Industrial Power Applications

46-81—Modern Diesel-Electric Drilling Rig Equipment; *T. R. Rhea (A '41). 25 cents.* A modern Diesel-electric powered drilling equipment for drilling oil wells consists of several internal combustion engines driving d-c generators which supply adjustable voltage power to the several d-c motors driving the various motions. This paper gives: a description of the functions performed by the draw works, mud pumps, rotary table, and coring reel; a typical arrangement of apparatus or elementary power diagram showing the main d-c circuits with the arrangement of drill hoist contactors and manual transfer switches; the general scheme of operation, strictly from the driller's point of view, without the details of how these functions are accomplished; the operating principles of the electrohydraulic governor that make this scheme of operation possible as well as the various control features provided by the amplidyne excitation of the main generators.

Protective Devices

46-80—A New Electronic Timing Relay for Reducing Outages on Power Circuits; *F. S. Dlouhy (A '39). 15 cents.* This paper describes a new timing relay for controlling relaying time on automatically reclosed circuit breakers on which inverse-time overcurrent relays are supplemented by instantaneous overcurrent relays. This device incorporates the advantages of instantaneous circuit breaker opening on the first, and in some cases the second, tripout to clear transient faults, and inverse-time opening on subsequent tripouts to obtain co-ordination with branch or sectionalizing fuses. It was designed for universal application on feeder circuits of the Oklahoma Gas and Electric Company system. And it was designed with certain features which provide for optimum service reliability.

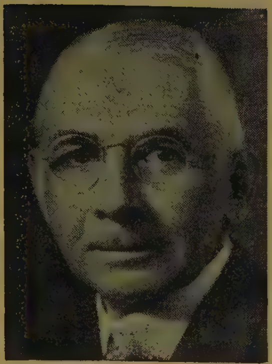
46-83—Operating Experience with Distance Ground Relays; *W. A. Wolfe (M '36). 20 cents.* The theory of distance ground relaying has been known since 1931, and distance ground relays have been commercially available since about 1936, but they have not been very generally used. In this paper a brief résumé of the theory of distance ground measurement is presented, and the advantages and disadvantages of such relays are outlined. Operating experience involving 10 installations of distance ground relays on a 60-kv transmission system is given. The first installation was completed in 1938 and the latest in 1943.

PERSONAL • • • •

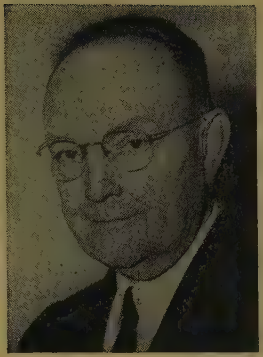
David Chandler Prince (A '16, F '26) vice-president, general engineering and consulting laboratory, General Electric Company, Schenectady, N. Y., has been awarded the AIEE Lamme Medal for 1945 "for his distinguished work in the development of high voltage switching equipment and electronic converters." Born February 5, 1891, in Springfield, Ill., Doctor Prince was graduated from the University of Illinois in 1912 with the degree of bachelor of science in electrical engineering and received the degree of master of

Bachrach

D. C. Prince



W. I. Slichter



J. E. Housley

science in 1913. After a brief interval in the test department of the General Electric Company, he became assistant to the electrical engineer of the Public Utilities Commission of Illinois in 1914, in which position he remained until he was commissioned first lieutenant in the United States Army in 1917. At the end of the war he returned to the General Electric Company and was attached to the radio department until in 1923 he entered the research laboratory. In 1931 he was transferred to the company's Philadelphia works as chief engineer of the switchgear department. He went back to Schenectady as manager of commercial engineering in 1940 and in 1941 was made vice-president of application engineering. He was appointed vice-president of the general engineering and consulting laboratory in 1945. Doctor Prince was president of AIEE for 1941–42 and a director for 1938–41. He has served on many AIEE committees including protective devices, Lamme Medal, board of examiners, finance, Edison Medal, Charles LeGeyt Fortescue Fellowship, transfers, air transportation, planning and co-ordination, and the joint committee on postwar planning, and has represented the Institute on the John Fritz Medal Board of Award and the Charles A. Coffin Fellowship and Research Fund Committee. Doctor Prince was chairman of the AIEE Philadelphia Section for 1940–41. He holds the honorary degree of doctor of science from Union College, is the author of technical papers, and has had many United States patents issued in his name. He was selected as a modern pioneer of industry in 1940. Doctor Prince also is a member of the American Society of Mechanical Engineers, the Institute of Aeronautical Sciences, the Society of Automotive Engineers, and the Institute of Radio Engineers. Recently he has been occupied in postwar planning activities for the Committee for Economic Development as well as for the General Electric Company.

J. E. Housley Nominated for AIEE President

J. Elmer Housley (A '19, M '39, F '43) district power manager, Aluminum Company of America, Alcoa, Tenn., has been nominated to serve as president of the AIEE for the 1946–47 term. Mr. Housley was born in Knoxville, Tenn., January 9, 1893, and was graduated from the University of Tennessee with the degree of bachelor of science in electrical engineering in 1915. He joined the Aluminum Ore Company, East St. Louis, Ill., in 1915 and in 1922 joined the Aluminum Company of America's sales organization, serving as sales engineer in the Kansas City (Mo.) office until 1923. In the latter year he returned to the Aluminum Ore Company and for a year was engaged in special engineering work. In 1924 he became assistant district electrical superintendent for the Aluminum Company of America, Alcoa, and in 1927 he was made superintendent of power, a position he held until 1943, at which time he was named district power manager. Mr. Housley has been an active member of the Institute. He was vice-president for the Southern District (4), 1941–43; chairman, Tennessee Section 1938–39, and is serving on many committees including technical program, 1944–47; Standards, 1944–47; and electrochemistry and electrometallurgy, 1939–47; chairman, 1944–46. He has contributed a number of articles to the technical press and various engineering societies. Other details on Mr. Housley's career were given in *Electrical Engineering*, November 1944, page 413.

W. I. Slichter Renominated for Office of AIEE Treasurer

Walter Irvine Slichter (A '00, M '03, F '12) professor emeritus of electrical engineering, Columbia University, New York, N. Y., has been renominated AIEE treasurer, an office he has held since 1930. A native of St. Paul, Minn., Mr. Slichter was graduated from Columbia University with the degree of electrical engineer in 1896. After an association of seven years with the General Electric Company, Schenectady, N. Y., he was appointed professor and head of the department of electrical engineering at Columbia University in 1910 and has been professor emeritus since 1941. Mr. Slichter has been very active in Institute affairs. He is on the board of directors, 1946–47, and is a member of the following committees for 1946–47: Edison Medal, executive, and Standards and was chairman of the committee on inter-American engineering co-operation and AIEE representative on the Joint Committee on Inter-American Engineering Co-operation.

Davis, Buckley, LeClair, Danner and Terrell Are Nominated for Vice-Presidents

Ernest Walter Davis (A '15, M '21, F '34) chief electrical engineer, Simplex Wire and Cable Company, Cambridge, Mass., has been nominated as AIEE vice-president for the North Eastern District (1) for 1946–47. Mr. Davis was born March 3, 1890, in Auburn, Maine, and was graduated from the Massachusetts Institute of Technology in 1913 with the degree of bachelor of science. Immediately thereafter he entered the employ of the Simplex Wire and Cable Company as assistant electrical engineer. In this capacity he assisted in carrying on the general electrical engineering work connected with the manufacture of insulated wires and was instrumental in the development of the manufacture of high-voltage paper cables. He conducted an extended research of the properties of the steel taped cables. In 1932 Mr. Davis was promoted to the position of electrical engineer. He has had seven years' experience teaching in industrial evening schools, including three years as instructor in electrical engineering at the Franklin Union Evening School, Boston, Mass., and has served as chairman of an advisory committee on the study of dielectrics for the electrical engineering department of the Massachusetts Institute of Technology, Cambridge. He served as president of the Insulated Power Cable Engineers Association in 1933. He is the author of many papers and articles and has prepared written discussions on various cable papers presented at AIEE meetings. He has served on the following AIEE committees: applications to marine work, 1939–40, and power transmission and distribution, 1939–43.

Oliver Ellsworth Buckley (M '19, F '29) president, Bell Telephone Laboratories, Inc., New York, N. Y., has been nominated as AIEE vice-president for the New York District (3). Mr. Buckley was born in Sloan, Iowa, August 8, 1887, and received a bachelor of science degree from Grinnell College in 1909 and a doctor of philosophy degree from Cornell University in 1914. After a year's service as instructor in physics, Grinnell (Iowa) College, he went to Cornell University, Ithaca, N. Y., as assistant and then as instructor in physics (1912–14). For the next three years he worked in the engineering department of the Western Electric Company, New York, N. Y. During World War I he served as major in the United States Signal Corps. In 1919 he returned to the Western Electric Company as a member of the technical staff in the engineering department. From 1925 until 1928 he was a member of the technical staff, Bell Telephone Laboratories, Inc., New York, N. Y., and in the latter year became assistant director of re-

J. F. Fairman

T. G. LeClair

Conway

O. E. Buckley

search. He became director of research in 1933, executive vice-president in 1937, and president in 1940. Mr. Buckley is the author of several technical articles and papers and holds many patents. He has been active in AIEE affairs and has been a member of the following committees: electrophysics, 1926–37, chairman, 1929–31; meetings and papers, 1929–31; research, 1934–40; Charles LeGeyt Fortescue fellowship, 1939–45, chairman 1941–45; Edison Medal, 1944–49; and technical program, 1946–47.

Charles Foster Terrell (A '10, M '18) vice-president, Puget Sound Power and Light Company, Seattle, Wash., has been nominated as AIEE vice-president for the North West District (9). Mr. Terrell was born in Jerseyville, Ill., May 1, 1885, and received a bachelor of science degree in electrical engineering from the University of Washington in 1910. For six years from 1903 to 1909 while he was a student at the University of Washington he was substation operator of the Seattle Electric Company. Later he was load dispatcher, supervisor of boiler room practice, and from 1911 to 1913 he was general foreman of substation construction of the Seattle Electric Company and of the Puget Sound Traction, Light, and Power Company when the latter was formed in 1912. Subsequently, Mr. Terrell was substation construction engineer, superintendent of substations of the Puget Sound Traction, Light, and Power Company and in 1916 was appointed superintendent of transportation in charge of operation, maintenance, and construction of all substations operated by the company in Seattle and in smaller cities of the Puget Sound district. In 1922 he was named superintendent of light and power for the company's northwest division, Bellingham, Wash. Two years later Mr. Terrell was made superintendent of light and power of the El Paso (Tex.) Electric Company. Later he joined the staff of the Tampa (Fla.) Electric Company as general superintendent. In 1929 he became identified with the Gulf States Utilities Company, Beaumont, Tex., and was serving as operating manager when in 1941 he was appointed operating manager of the Puget Sound Power and Light Company. He became vice-president in 1944. Mr. Terrell served for two years, 1916 and 1917 as secretary of the AIEE Seattle Section.

Titus George LeClair (A '24, M '29, F '40) staff engineer, Commonwealth Edison Company, Chicago, Ill., has been nominated as AIEE vice-president for the Great Lakes District (5). He was born in Superior, Wis., August 26, 1899, and was graduated from the University of Idaho in 1921 with a bachelor of science degree in electrical engineering. After one year in the test course of the General Electric Company, Schenectady, N. Y., he became associated with the Commonwealth Edison Company as cable engineer. Subsequently he was substation field engineer (1924–27); engineer of system protection (1927–30); engineer, electrical engineer's office (1930–32); and development engineer (1932–36). He was appointed supervising development engineer in 1936 and recently was appointed staff engineer. Mr. LeClair has several relaying and control inventions to his credit. He has presented various papers before the AIEE conventions and Section meetings and has been generally active in Institute affairs. He was a director, 1941–45, and has served on many committees. They include the following: special committee on registration of engineers, 1942–47; planning and co-ordination, 1943–47; constitution and bylaws, 1944–47; Edison Medal, 1942–44; Standards, 1942–43; technical program 1942–43; and committee on Student Branches 1946–47. Mr. LeClair has been a member and trustee of the Western Society of Engineers, member of the Illinois Society of Engineers, and a director of the Illinois Engineering Council.

Ronald Fackler Danner (A '29, M '34, F '45) general superintendent, Oklahoma Gas and Electric Company, Oklahoma City, has been nominated as AIEE vice-president for the South West District (7). Mr. Danner was born in Astoria, Ill., November 2, 1897, and was graduated from the University of Oklahoma with a bachelor of science degree in electrical engineering in 1920. After a short period as electrical engineer with a consulting engineering firm in Oklahoma City, he entered the employ of the Oklahoma Gas and Electric Company in 1921 as electrical distribution engineer. A year later he was made assistant superintendent of the electrical department in charge of distribution system engineering. From 1923 to 1926 he was assistant to the general superintendent working in the capacity of assistant engineer, and in 1926 he was appointed general superintendent with supervision of the company's electrical engineering and operating departments. He has served as a member of the foreign systems committee of the National Electric Light Association, and when the Edison Electric Institute was organized he became a member of its transmission and distribution committee and served on important subcommittees of that committee. In 1937 and 1938 he was secretary of the Oklahoma Society of Professional Engineers. Mr. Danner was a member of the AIEE committee on power transmission and distribution, 1940–45. He has served on various local committees of the Oklahoma City Section and was vice-chairman and chairman of that Section for the years 1932–33 and 1933–34, respectively.

Grady

C. F. Terrell

Marquis

R. F. Danner

Bachrach

E. W. Davis

Fairman, Henry, Yerkes Nominated for Directorships

James Ferdinand Fairman (A '20, M '27, F '35) vice-president in charge of production and operation, Consolidated Edison Company of New York (N. Y.), has been nominated to serve on the AIEE board of

L. B. Chubbuck

R. T. Henry

Bachrach

E. P. Yerkes

directors. Mr. Fairman received the degrees of bachelor of science in electrical engineering (1918) and master of science (1921) from the University of Michigan. In 1925 he joined the Brooklyn (N. Y.) Edison Company. Following the merger of various companies into the Consolidated Edison Company he became electrical engineer for the system. In 1941 he was appointed assistant vice-president for design, inventory, purchasing, and stores. He was appointed vice-president in 1946. Mr. Fairman has been very active in Institute affairs and has served on many committees. He was AIEE vice-president for the New York, N. Y., District (3) for 1944–45. For further biographical details see *Electrical Engineering*, February 1946, page 85, and March 1944, page 110.

Raymond T. Henry (A '24, M '29, F '33) chief electrical engineer, engineering department, Buffalo (N. Y.), Niagara, and Eastern Power Company, has been nominated to serve on the AIEE board of directors. He has served the Niagara Falls (N. Y.) Hydraulic Power and Manufacturing Company, Hooker Electrochemical Company, Niagara Falls; Edison Illuminating Company, Detroit, Mich., and the Niagara Electric Service Corporation. He has been electrical engineer and assistant chief electrical engineer for the Buffalo, Niagara, and Eastern company. Mr. Henry has been active in Institute affairs and has served on many committees. He was awarded the 1933 AIEE national prize for the best paper on engineering practice. For further biographical data see *Electrical Engineering*, September 1945, page 335, and March 1944, page 110.

Earle Pierce Yerkes (A '15, F '40) engineer of equipment and buildings, Eastern area, Bell Telephone Company of Pennsylvania, Philadelphia, has been nominated to serve on the AIEE board of directors. Mr. Yerkes was born in Chester County, Pa., May 28, 1892, and was graduated from the University of Pennsylvania (1912) with a bachelor of science degree in electrical engineering. For two years after graduation he was student engineer with the Bell Telephone Company of Pennsylvania, and successively was specification writer, supervising specification writer, and engineering assistant, and in 1920 he became assistant engineer. From 1922 to 1925 Mr. Yerkes held the position of superintendent of machine switching equipment, and for the next two years he served as division superintendent of equipment. Subsequently, he was plant supervisor, superintendent of buildings and supplies, and engineer of equipment and in 1933 was appointed engineer of equipment and buildings. In 1938 he was detached temporarily from his regular assignment to take responsibility for inventory and appraisal of entire office, private branch exchange, and telephone station plant of the Bell Telephone Company of Pennsylvania. Mr. Yerkes has taken an active part in AIEE affairs. He is a member of the following committees: membership, 1942–47; communication, 1942–47; and special committee on collective bargaining and related matters, 1944–47.

L. B. Chubbuck (A '18, M '26, F '43) formerly assistant chief engineer, Canadian Westinghouse Company, Ltd., Hamilton, Ontario, has been appointed consulting engineer of the company. Mr. Chubbuck was born in November 1879 in Ottawa, Ontario, Canada, was graduated from the University of Toronto in 1899, and later received the degree of electrical engineer. He spent the nine years succeeding his graduation with the Westinghouse Electric Corporation, East Pittsburgh, Pa., on general switching equipment and in 1909 was transferred to the Canadian Westinghouse company as engineer in charge of switching equipment and in this position was a pioneer in the development of metal-clad switchgear. He was appointed assistant chief engineer in 1936. Mr. Chubbuck has been the author of several papers on switching equipment and is a past chairman of the Toronto Section and was AIEE vice-president for 1931–33.

E. F. Carter (A '25) director of industrial relations since 1941, Sylvania Electric Products, Inc., New York, N. Y., has been elected a vice-president in charge of industrial relations. Mr. Carter joined the company in 1932.

E. T. B. Gross (A '34, M '40) formerly assistant professor of electrical engineering, College of Engineering, Cornell University, Ithaca, N. Y., has been appointed professor of electric power system enigineerng, Illinois Institute of Technology, Chicago. Born in Vienna, Austria, in 1901, Doctor Gross received the degrees of electrical engineer in 1923 and doctor of technical sciences in 1932 from the University of Vienna. Prior to his entering the United States in 1939, Doctor Gross was an instructor at the Institute of Technology, Vienna (1921–24) and had been associated with AEG Union Electric and Manufacturing Company in Vienna from 1924 to 1938 and after 1938 with the British Company in London, England. He joined the staff of Cornell University as research associate in 1940, and, after a period as instructor of electrical engineering at the College of the City of New York (N. Y.), he returned to Cornell as assistant professor of electrical engineering in 1942. Doctor Gross served as consultant to the United States War Department from 1942 to 1944. He holds a number of patents and is the author of technical papers. He served as chairman of the section on high voltage systems protection and grounding at the International Conference on Large High Voltage Power Systems in 1937. Since 1940 he has been active in AIEE Section and Branch affairs and on technical groups.

L. W. Morton (A '38) formerly application engineer on power rectifiers, industrial engineering divisions, General Electric Company, Schenectady, N. Y., has been appointed head of the new power electronics division of the company. Mr. Morton, a graduate of the University of Minnesota, joined the General Electric Company in 1924 as a student engineer and has been application engineer since 1941. **M. A. deFerranti** (M '43) formerly assistant chief, aerodynamics department, research laboratory, Curtiss Wright Corporation, Buffalo, N. Y., has been named engineer of the new materials handling and testing equipment division of the General Electric Company. Mr. deFerranti, a graduate of the Sydney Technical School and a former employee of the Australian General Electric Company, Ltd., was first associated with the General Electric Company in 1929. Later that year he was transferred to the International General Electric Company, returning to Schenectady as application engineer. From 1943 until his return to the General Electric Company in 1945 he was employed by the Curtiss-Wright Corporation.

E. L. Bowles (A '22, F '33) expert consultant to the United States Secretary of War and communications consultant to the commanding general, Army Air Forces, recently was awarded the Distinguished Service Medal for his services to the Army Air Forces. Doctor Bowles was commended for organizing an advisory group composed of electronics specialists, for securing the aid of leaders in scientific and industrial laboratories, and for placing scientific personnel on the staffs of all major AAF commands. Doctor Bowles, who has been on leave of absence as professor of electrical communications, Massachusetts Institute of Technology, Cambridge, since 1942, was particularly concerned with plans for the antisubmarine warfare in the Atlantic and for combating the "buzz bomb" assaults in England. In 1945 Doctor Bowles also was awarded the honorary degree of doctor of science by Norwich University, Norfolk, England.

L. J. Linde (A '39, M '45) formerly assistant to the managing engineer of the power circuit breaker division, General Electric Company, Philadelphia, Pa., has been appointed chief engineer of the A. B. Chance Company, Centralia, Mo. Mr. Linde holds the bachelor of science degree in mechanical engineering from South Dakota State College. He entered the employ of the General Electric Company in 1929 as student engineer and was named design draftsman in 1930 and design engineer in 1932. As design engineer and development engineer, which he became in 1937, he was twice the recipient of a joint Charles A. Coffin Award of Merit, the first for work on an a-c network protector, and the second for development of the Magne-blast oilless circuit breaker. Mr. Linde was made assistant to the managing engineer of the power circuit breaker division in 1941.

F. H. King (A '31, M '40) who has been provisional manager of the Holyoke (Mass.) Gas and Electric Department since October 1945, has been appointed manager. Mr. King, a 1928 graduate of Worcester Polytechnic Institute, entered the Holyoke department as a draftsman in 1931. He was named electrical engineer in 1932 and assistant superintendent of the electric station in 1933. In 1937 he was loaned to the Electric Light Department of the City of Burlington, Vt., and continued as superintendent of that department until in 1941 he was appointed power consultant on the staff of the power division of the Office of Production Management. He served on the Army and Navy Munitions Board in 1942 and later, as a lieutenant colonel, was chief of the electronics section of the resources division at Army Air Forces headquarters.

A. G. Grier (A '04) manager, distribution equipment division, Canadian General Electric Company, Ltd., Toronto, Ontario, Canada, has retired. Mr. Grier was born in Ottawa, Ontario, in 1878 and was graduated from McGill University in 1899 with the degree of bachelor of science. In 1901 he received the degree of master of science. Early in his career Mr. Grier was associated for snort periods with the Stanley Electric Company, the Western Electric Company, Allis-Chalmers Manufacturing Company in the United States, and the Royal Electric Company of Montreal, Quebec, Canada. In 1906 he became partner in the firm of Wescott and Grier, Montreal, and from 1911 to 1919 practiced engineering in Peterboro, Ontario. He joined the Canadian General Electric Company, Peterboro, in 1920 as assistant to the general superintendent. In 1926 he was named distribution engineer.

V. W. Bergenthal (A '01) treasurer and director, Wagner Electric Corporation, St. Louis, Mo., retired December 31, 1945 but will continue to serve as a director. A native of Milwaukee, Wis., Mr. Bergenthal received from the University of Wisconsin a bachelor of science degree in electrical engineering (1897) and the degree of electrical engineer (1898). In the latter year he entered the engineering department of Stanley Electric Manufacturing Company, Pittsfield, Mass. He went to California in 1900 as assistant engineer of the Bay Counties Power Company. He returned to the Stanley company in Pittsfield and was placed in charge of transformer design. In 1901 he went to the Chicago (Ill.) office and in 1903 was appointed assistant manager. Later in 1903 he became electrical engineer and secretary, American Automatic Switch and Signal Company, Chicago, Ill. In 1904 Mr. Bergenthal joined the staff of the Wagner Electric Company and has served as manager, purchasing agent, treasurer, and treasurer and director.

L. M. Smith (M '36) director of public relations, Alabama Power Company, Birmingham, has been elected a vice-president of the company. Mr. Smith was graduated from the University of Alabama with the degree of bachelor of science in 1916 and for a time was employed by the Navy Department at Norfolk, Va., and by the Tennessee Coal, Iron, and Railroad Company, Birmingham. From 1923 to 1931 he was associated with the Dixie Construction Company and it successor, Allied Engineers, Inc., Birmingham, and in this connection supervised the construction for the properties of the Commonwealth and Southern Corporation in six southern states. In 1931 he joined the Alabama Power Company as electrical engineer and in 1937 was given the title chief engineer. He became director of public relations in 1944.

J. C. Peet (A '08, M '22) chairman of the electrical engineering department, Newark College of Engineering, Newark, N. J., has retired. Professor Peet was born in Webster, N. Y., in 1880, and was graduated from Syracuse University with the degree of electrical engineer in 1903. After a short time with the General Electric Company, Schenectady, N. Y., he turned to teaching at the Mechanics Institute, Rochester, N. J., from 1907 to 1910, and at the Harrisburg (Pa.) Technical High School from 1910 to 1917. He became professor of physics at Toledo (Ohio) University in 1917 and in 1918, at the inception of the Newark College of Engineering, assumed the chairmanship of the electrical engineering department. Professor Peet is a member of the Society for the Promotion of Engineering Education and Tau Beta Pi.

A. A. Nims (A '11, M '28) professor of electrical engineering, Newark College of Engineering, Newark, N. J., has been elected chairman of the electrical engineering department of the college. Born in Montague, Mass., in 1886, Professor Nims was graduated from Worcester Polytechnic Institute in 1908. After graduation he was for a time instructor at the Institute. His industrial experience includes work with the Murphy Electricity Rectifier Company, Rochester, N. Y., in 1911; a period with the Crocker-Wheeler Company, Ampere, N. J., from 1912 to 1919; and one with the Siemund-Wenzel Electric Welding Company, New York, N. Y., from 1919 to 1922. In 1922 he joined the faculty of the Newark College of Engineering as instructor, becoming assistant professor in 1924, and associate professor in 1926. He was named full professor in 1932.

K. V. Farmer (M '21) formerly general manager of the Canadian Ohio Brass Company, Ltd., Niagara Falls, Ontario, has been elected a vice-president of the company. Mr. Farmer, who was born in Newark, Ohio, and was graduated from Swarthmore College, was associated with the Syracuse (N. Y.) Lighting Company from 1913 to 1924 at first in the meter, distribution, and production departments. In 1916 he was placed in charge of the completion of duct system and substations. He became assistant to the superintendent of the electric department in 1917, assistant superintendent in 1918, and superintendent in 1922. After a short period with the Ohio Insulator Company, Barberton, he joined the Ohio Brass Company, Mansfield, in 1925 and was named district engineer in 1927. About 1933 he became manager of the Canadian Ohio Brass Company.

I. C. Smith (A '30) engineer of the d-c engineering department, Crocker-Wheeler division, Joshua Hendy Iron Works, Ampere, N. J., has been appointed chief engineer of the company. Mr. Smith, who was born in St. Philip de Chester, Quebec, Canada, in 1899, received the degrees of bachelor of arts in 1920 and electrical engineering in 1922 from Cornell University. Mr. Smith commenced his career as design engineer with the Westinghouse Electric Corporation in 1922. He continued his work on d-c machine design when he became associated with the Elliott Company, Reading, Pa., in 1930, and in 1939 he assumed charge of that work for the company. In 1942 he joined the Crocker-Wheeler Company.

J. F. Rider (A '28) recently lieutenant colonel in the Army Signal Corps, and president of John F. Rider, Publisher, Inc., New York, N. Y., has been presented with the Legion of Merit medal. The citation for Colonel Rider, who spent 3½ years in military service, read in part "... rendered exceptional administrative service to the Signal Corps publication agency. . . . His ability to organize and utilize effectively available personnel materially contributed to the preparation, production, and distribution of vitally needed technical manuals containing instruction for the installation, operation, maintenance, and repair of signal equipment."

G. J. Irwin (A '44) formerly chief engineer, Philco Corporation of Canada, Toronto, Ontario, is now engineer, radio division, Royce Avenue works, Canadian General Electric Company, Ltd., Toronto. Born in Toronto in 1905, Mr. Irwin's first engineering position was that of laboratory assistant for the De Forest Crossley Radio Company, Toronto, in 1929. He was assistant engineer with the Williams Piano Company, Oshawa, from 1930 until in 1932 he became assistant engineer for the Philco corporation. He had been chief engineer since 1935. Mr. Irwin is vice-chairman of the engineering committee of the Radio Manufacturers' Association of Canada, coordinator of the Canadian Radio Technical Planning Board, and a representative of the radio industry on the main committee of the Canadian Standards Association.

W. L. Widlar, Jr. (A '43) project engineer for the Mec-Rad division of Black Industries, Cleveland, Ohio, since November 1944, has been appointed general manager of that division. From 1933 to 1943 he was radio research engineer for WGAR Broadcasting Company, Cleveland, except when he was on leave of absence in 1942 to serve as research engineer member in New London, Conn., and New York, N. Y., of the laboratory staff of Columbia University's division of war research. In 1943 he became part-time research engineer for the Bird Engineering Company, Cleveland.

W. D. Coolidge (A '10, M '34) retired vice-president and director of research, General Electric Company, Schenectady, N. Y., and who recently has been touring South America, has been awarded the Order of Merit of the Chilean Government. Doctor Coolidge has received many honors, including Edison Medal, Faraday Medal, Franklin Institute Medal, and Washington Award. He has served on AIEE committees, including: electrophysics, 1927–29; Edison Medal, 1940–45; and applications of electricity to therapeutics, 1941–46.

F. E. Nutt (A '36) formerly Washington (D. C.) representative, Crocker-Wheeler Electric Manufacturing Company, has been named assistant sales manager, division of the company's Joshua Hendy Iron Works, Ampere, N. J. Mr. Nutt is a graduate of the University of Denver (1931) with a bachelor of science degree in electrical engineering. Since 1942 he has been associated with Crocker-Wheeler sales.

F. H. Pumphrey (M '25) is now educational service engineer, educational service division, General Electric Company, Schenectady, N. Y. He served as a lieutenant colonel, Signal Corps, Army of the United States, during World War II and prior to his receiving his commission, was professor of electrical engineering, Rutgers University, New Brunswick, N. J. He was a member of the AIEE communication committee, 1932–36, and publication committee, 1941–44.

W. J. Lind (A '36) formerly lighting service engineer, lamp and lighting division, Canadian General Electric Company Limited, Vancouver, British Columbia, has been made manager of that division. A graduate in mechanical engineering from the University of British Columbia, Mr. Lind joined the Canadian General Electric in 1937 after serving in the department of mechanical and electrical engineering as an instructor and lecturer at the University of British Columbia.

M. F. Beisber (A '37) transformer specialist for the Line Material Company on the West Coast, has been appointed sales manager of the transformer division of the company, Milwaukee, Wis., with headquarters in Zanesville, Ohio. He joined the sales organization of the company in 1933 as field engineer for the Memphis (Tenn.) district. In 1941 he went to the San Francisco (Calif.) office.

L. J. Olivier (A '39) superintendent, transformers and stores department, Louisiana Power and Light Company, New Orleans, is now with the Graybar Electric Company, New Orleans, as merchandising manager. Mr. Olivier became associated with the Louisiana Power and Light Company in 1927.

G. A. Loveless (A '28, M '36) formerly manager, instrument division, Sangamo Electric Company, Springfield, Ill., has been named district manager, north central district, with headquarters in Minneapolis, Minn. Mr. Loveless is a graduate of Washington University with a bachelor of science degree in electrical engineering. He was a member of the AIEE membership committee, 1937–38.

OBITUARY • • • •

Frank Fuller Fowle (A '02, M '12) head of the consulting engineering firm, Frank F. Fowle and Company, Chicago, Ill., died January 21, 1946. Born in San Francisco, Calif., November 29, 1877, Mr. Fowle received the degree of bachelor of science from Massachusetts Institute of Technology in 1899. In his first position from 1899 to 1903 as assistant electrician in the engineering department of the American Telephone and Telegraph Company, New York, N. Y., Mr. Fowle was active in the development of the Pupin loading system. In 1903 he was made special agent in the company's railway department and was one of the pioneers in the introduction of the telephone for railway dispatching. He became manager of the Chicago operating territory of the company's long-distance system in 1906. He was a consultant in Chicago from 1908 to 1912, then going to New York, as associate editor of *Electrical World* for one year and as consulting engineer for one year. He was named receiver of the Central Union Telephone Company in 1914. He was a member of the firm of Fowle and Cravath, Chicago, in 1919 and 1920, and in 1920 became head of the firm, Frank F. Fowle and Company. Mr. Fowle was author of many technical papers and articles and had been editor in chief of the "Standard Handbook for Electrical Engineers" since 1913. He was an AIEE manager from 1919 to 1923, served as president of the Western Society of Engineers in 1935 and 1936 and as president of the Illinois Engineering Council. He was also a member of the Illuminating Engineering Society, the American Society for Testing Materials, the Association of American Railroads, and the American Society for Metals. Active in community affairs, Mr. Fowle had served on the Winnetka, Ill., Board of Education, the Winnetka Zoning Commission, and the Zoning Board of Appeals. He was consulting engineer to the National Electric Light Association from 1920 to 1932.

Hugh Alexander Laidlaw (A '09, M '36) assistant engineer of operation, Pacific Gas and Electric Company, San Francisco, Calif., died December 15, 1945. Mr. Laidlaw was born in Portland, Oreg., March 20, 1880. He commenced his electrical career with the Portland General Electric Company, later the Portland Railway Light and Power Company, with which he was associated from 1898 to 1907 as shop apprentice, as member of the street lighting department and meter department, as station operator, inspector, chief inspector, and as assistant to the chief electrical engineer. In 1907 he went to Nome, Alaska, as general superintendent of the Nome Electric Light and Power Company. He entered the employ of the Pacific Gas and Electric Company as engineering assistant to the chief electrical engineer and was named assistant engineer of operation in 1923.

William Germain Vincent (A '05) vice-president and executive engineer, Pacific Gas and Electric Company, San Francisco, Calif., died January 29, 1946. Mr. Vincent was born August 11, 1882, in New Orleans, La., and held the degrees of bachelor of engineering from Tulane University of Louisiana (1902) and of mechanical engineer from Cornell University (1904). Mr. Vincent was associated with the Gray Telautograph Company from 1902 to 1906 in

New York, N. Y., and in San Francisco, Calif. After brief interludes with the Ocean Shore Railway Company, C. L. Cory, construction engineer, and J. G. White and Company, he joined the Pacific Gas and Electric Company in 1912, as valuation engineer. In 1922 he became vice-president and executive engineer. He was also a vice-president and member of the board of directors of the Standard Pacific Gas Line Company and a past president of the Engineers Club of San Francisco.

Baldwin Drew Ward (A '45) electrician, Oakland (Calif.) Army Base, died January 18, 1946. Mr. Ward was born in Lindly, N. Y., December 4, 1880. Mr. Ward gained his early experience in electrical contracting doing repair and installation work in New York, N. Y., Philadelphia, Pa., Detroit, Mich., and St. Louis, Mo. Before 1917 he worked as station operator and foreman for the St. Louis Signal and Power Company, the Fort Worth (Tex.) Signal and Power Company, Stone and Webster, Inc., the Pacific Signal and Power Company, and the Cowell-Portland Cement Company. From 1917 to 1920 he worked as subforeman for the Moore Shipbuilding Company, Oakland. Thereafter he operated as a licensed contractor in the state of California. In 1942 he became electrical inspector for the utilities and marine repair shop of the United States Army Engineers, Oakland. Mr. Ward was an AIEE Associate from 1911 to 1919 and from 1921 to 1924.

Edward Holder (A '13, M '44) formerly superintendent of metering, operating department, Shawinigan Water and Power Company, Montreal, Quebec, Canada, died December 20, 1945. Mr. Holder was born at Kingston, Surrey, England, May 30, 1888, and was graduated from the University of London in electrical engineering in 1908. His first job was assistant testing engineer, Newcastle (England) Electric Supply Company. In 1911 he went to Canada and was employed by the British Columbia Electric Railway Company, Vancouver, as district representative in the light and power department. In 1916 he enlisted in the Royal Canadian Engineers and after his discharge joined the staff of the Shawinigan company as meter engineer. In 1943 he was made superintendent of the meter division. Mr. Holder was chairman of the Canadian Electrical Standards Association's watt-hour meter committee and a member of the associate committee of the National Research Council on electrical measuring instruments.

Albert Raiguel Bingham (A '07, M '21) retired, general superintendent, Canadian Light and Power Company, St. Timothee, Quebec, Canada, died January 4, 1946. Mr. Bingham was born in Philadelphia, Pa., March 30, 1878, and was graduated from Drexel Institute of Technology in electrical engineering in 1900. He engaged in various enterprises early in his career, with D'Olier Engineering Company, electrical contractors of Philadelphia, an electrical contracting business of his own at Housatonic, Mass., with the Berkshire Street Railway, Housatonic, construction work on the power plant of the Monument Mills Company, Glendale, Mass., with the power plants of the Hudson River Electric Power Company at Utica and Spier Falls, N. Y., and from 1909 to 1913, with the power plant of the Aluminum Company of America, Massena, N. Y. In the latter year he began his association with the Canadian Light and Power Company as assistant superintendent. Later he was promoted to superintendent.

Clarence Albert Price (A '19, M '39) formerly chief engineer, Canadian Westinghouse Company, Ltd., Hamilton, Ontario, Canada, died December 29, 1945. Mr. Price was graduated as electrical engineer from Drexel Institute of Technology in 1898. For the first four years of his career he was general contractor on electrical work, with J. A. Roebling's Sons and with the Bell Telephone Company of Philadelphia (Pa.) on the electrolysis survey of underground cable. In 1902 he became associated with the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., and in 1906 changed to the Canadian Westinghouse Company, Hamilton, in charge of induction motor and transformer design. He became assistant chief of the company in 1919 and in 1936 was appointed chief engineer. Mr. Price was AIEE vice-president for the District of Canada (10) from 1941 to 1943 and was an active member of the AIEE Toronto Section, having been chairman, 1934–35. He was also a member of the AIEE committee on Institute policy, 1941–42.

William August Petrasek (A '36) project engineer, American Airlines, Inc., LaGuardia Field, New York, N. Y., was killed in the crash of an airliner, January 31, 1946. Born July 16, 1914, in New York, Mr. Petrasek was graduated from New York University in 1935. He was employed as engineering draftsman and laboratory assistant by the Diehl Manufacturing Company, Elizabethport, N. J., until 1937 when he became assistant instructor of electrical engineering at New York University, New York. In 1940 he joined American Airlines as electrical engineer and was given the title project engineer in 1944. Mr. Petrasek was a member of the AIEE committee on air transportation. He was a member of Tau Beta Pi and had published an article in *Electrical Engineering* and technical papers in AIEE *Transactions*.

Myrick Whiting Pullen (A '07, M '29) associate in electrical engineering, Johns Hopkins University, Baltimore, Md., died January 10, 1946. Professor Pullen was born in Whiting, Iowa, January 25, 1883, and was graduated from the University of Iowa. He was an instructor at Iowa State College, Ames, from 1908 to 1910 and in the latter year joined the faculty of Johns Hopkins University as assistant in electrical engineering. He was named instructor in 1913 and associate in electrical engineering in 1920. Professor Pullen's research activities included work on formation of corona, the corona voltmeter, a memory testing machine, and development of a special circuit breaker. He also had done research work for the United States Bureau of Mines. He was a member of the AIEE committee on production and application of light from 1940 to 1943.

Henry Van deVere Putman (A '23, M '32) vice-president, Westinghouse Electric Corporation, Sharon, Pa., died January 16, 1946. Mr. Putman, who was born May 27, 1899, in Barker, N. Y., studied at Union College from which he received the degrees of bachelor of science, master of science, and doctor of philosophy. Before joining the Westinghouse Corporation as design engineer in 1925, Mr. Putman was design engineer and assistant chief engineer with the Ideal Electric Manufacturing Company, Mansfield, Ohio. He was named section engineer in 1928, and was transferred to Sharon, Pa., in 1929 as assistant manager of the transformer engineering department. He became manager of the department in 1931, and later manager of the division. In 1942 he was elected a vice-president. He had served on the AIEE committees on electric machinery and power transmission and distribution.

Arthur Francis Ward Richards (A '17, M '39) consulting engineer and member of the firm, Richards and Bright, London, England, died January 25, 1946. Mr. Richards was born September 1, 1877, in Bristol, England, and attended Haileybury College. He commenced his career with the Hastings Electric Light Works, London, in 1894 and became assistant engineer with the Reading Electric Light Works, London, in 1897. He was appointed assistant engineer for the County of London Electric Supply Company, Ltd., in 1901 and from 1906 to 1919 was engineer in the contract department of W. T. Glover and Company, Ltd., Manchester, England. Since 1919 he had practiced as a consulting engineer.

Wheeler Newman Voorhees (A '10) retired, General Electric Company, New York, N. Y., died January 18, 1946. Mr. Voorhees was born in Brooklyn, N. Y., January 20, 1870 and attended New York University. In 1889 he began work with the Westinghouse Electric and Manufacturing Company, Newark, N. J., and the following year he was employed by the Coney Island and Brooklyn Railroad Company. In 1900 Mr. Voorhees entered the employ of the General Electric Company as electrical construction foreman in charge of the company's reconstruction contract at the main station of the Metropolitan Street Railway Company. He was retired in 1932 after 32 years as a construction engineer.

MEMBERSHIP...

Recommended for Transfer

The board of examiners, at its meeting of February 21, 1946, recommended the following members for transfer to the grade of membership indicated. Any objections to these transfers should be filed at once with the secretary of the Institute.

To Grade of Fellow

Green, S., vice-pres. & chief engr., Aerovox Corp., New Bedford, Mass.
Hatch, P. H., general mech. supt., N. Y., N. H. & H. R. R. Co., New Haven, Conn.
Holliday, T. B., colonel, Air Corps, Wright Field, Dayton, Ohio.
Hughes, C. T., general supt., Connecticut Lt. & Pr. Co., Waterbury, Conn.
Sanford, F. E., supt., distribution engg., Cincinnati Gas & Elec. Co., Cincinnati, Ohio.
Simpson, W. L., chief elec. engr., Rio de Janeiro Tramway, Lt. & Pr. Co., Sao Paulo, Brazil, S. A.

6 to grade of Fellow

To Grade of Member

Andrews, G. E., Jr., distribution engr., Narragansett Elec. Co., Providence, R. I.
Angermann, W. G. B., assoc. prof. of elec. engg., University of Southern California, Los Angeles, Calif.
Arnold, W. O., member of technical staff, Bell Tel. Labs., Inc., New York, N. Y.
Atkinson, J. F., assoc. elec. engr., Rural Electrification Administration, Washington, D. C.
Brennecke, C. G., prof. and head, dept. of elec. engg., North Carolina State College, Raleigh, N. C.
Bussard, E. J. H., radio engineer, Crosley Corp., Cincinnati, Ohio
Button, C. T., sales manager, Master Elec. Co., Dayton, Ohio
Cohen, R. L., elec. squad leader, E. I. duPont de Nemours, Wilmington, Del.
Farrer, H. E., asst. to secy., Standards Committee, Board of Examiners, AIEE, New York, N. Y.
Ferguson, J. P., cons. and application engr., Westinghouse Elec. Corp., San Francisco, Calif.
Fitch, H. S., general supt. of substations, West Penn Power Co., Pittsburgh, Pa.
Fredrick, E. H., application engr., Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Greene, R. E., construction engr., Detroit Edison Co., Detroit, Mich.
Hanson, L. P., elec. engr., Boeing Aircraft Co., Seattle, Wash.
Hare, S. B., elec. engr. in charge of design, Sawyer Electrical Mfg. Co., Los Angeles, Calif.
Heinrich, H., mgr., general const. dept., Hawaiian Elec. Co., Ltd., Honolulu, T. H.
Higgins, L., supt., service shop, General Elec. Co., Cincinnati, Ohio.
Janssens, J. N., director and acting general mgr., Automatique Electrique, Antwerp, Belgium
Jenkins, D. F. L., elec. engr., Messrs. Johnson & Phillips, Ltd., Charlton, London, Eng.
Jordan, W., 3d, asst. prof., dept. of elec. engg., Newark College of Engg., Newark, N. J.
Kuhlman, L. G., pres. and general mgr., Wadsworth Elec. Mfg. Co., Inc., Covington, Ky.
Lamberton, A. F., elec. engr., Taylor Instrument Cos., Rochester, N. Y.
Lloyd, R. L., assoc. elec. engr., National Bureau of Standards, Washington, D. C.
Marvin, G. S., experimental engr., General Motors Corp., Flint, Mich.
Morgan, S. C., prof. of elec. engg., University of British Columbia, Vancouver, B. C., Canada
Noy, J. M., elec. engr., Climax Molybdenum Co. of Pennsylvania, Langeloth, Pa.
Phares, J. A., Southwest Elec. Co., Oklahoma City, Okla.
Reid, C. R., elec. engr., Hoover Co., North Canton, Ohio
Rue, H. E., sr. elec. engr., Hoover Co., North Canton, Ohio
Scott, E. O., chief electrician and head of elec. dept., Electro Metallurgical Co. of Canada, Ltd., Welland, Ont., Can.
Sheckels, G. D., asst. prof., dept. of elec. engg.; Montana State College, Bozeman, Mont.
Smith, E. P., design engr., General Elec. Co., Schenectady, N. Y.
Smith, I. C., chief engr., Crocker-Wheeler Elec. Mfg. Co., Ampere, N. J.
Smith, R. M., elec. engr., Railway & Industrial Engg. Co., Greensburg, Pa.
Smrz, G. L., exec. vice-pres., Line Material Co., Milwaukee, Wis.
Suransky, P., supt. of distribution, Pacific Gas & Elec. Co., Sacramento, Calif.
Wilhelm, H. T., member of tech. staff, Bell Tel. Labs., New York, N. Y.
Williams, N. A., elec. engr., Goodyear Tire & Rubber Co., Akron, Ohio
Williamson, E. T., vice-pres. chrg. of operation, Iowa-Illinois Gas & Elec. Co., Rock Island, Ill.
Zervigon, M. G., assoc. prof. of elec. engg., Tulane Univ., New Orleans, La.

40 to grade of Member

Applications for Election

Applications have been received at headquarters from the following candidates for election to membership in the Institute. Any member objecting to the election of any of these candidates should so inform the secretary before April 15, 1946, or June 15, 1946, if the applicant resides outside of the United States or Canada.

To Grade of Member

Ailleret, P. J., "Ecole Nationale des Ponts & Chaussees," Paris, France
Barnes, T. G., College of Mines and Metallurgy, El Paso, Tex.
Blankenburg, R. C., Southern California Edison Co., Ltd., Los Angeles, Calif.
Bourhill, D. A., Dunoon & District Electricity Supply Co., Ltd., Dunoon, Scotland
Briggs, D. K., Western Elec. Co., Kearny, N. J.
Burnham, A. H., Locke Insulator Corp., Baltimore, Md.
Cain, D. E., General Elec. Co., St. Louis, Mo.
Carey, J. J., University of Kansas, Lawrence, Kan.
Condit, S. B., The Chase-Shawmut Co., Boston, Mass.
Eldridge, L. C., Baton Rouge Water Works Co., Baton Rouge, La.
Friday, C. D., Bureau of Yards & Docks, Navy Dept., Washington, D. C.
Galle, P. F., Tennessee Eastman Co., Oak Ridge, Tenn.
Goldbach, L. A., Cleveland Switchboard Co., Cleveland, Ohio
Healy, H., Tennessee Eastman Corp. (CEW), Oak Ridge, Tenn.
Hietala, A. A., Public Service Elec. and Gas Co., Newark, N. J.
Hope, J., R. H. Bouligny, Inc., Charlotte, N. C.
Horney, M. J., Kansas City Power & Light Co., Kansas City, Mo.
Irwin, K. M., Philadelphia Elec. Co., Philadelphia, Pa.
James, V. E., Automatic Elec. Co., Chicago, Ill.
Johnson, E. C., Gibbs & Hill, Inc., New York, N. Y.
Jones, E. F., United Engineers & Constructors, Inc., Philadelphia, Pa.
Keirn, T. G., West Virginia Pulp and Paper Co., Charleston, S. C.
Kirk, H. P., Artcraft Elec. Supply Co., Wilmington, Del.
Krosnes, O. M., Tennessee Valley Authority, Knoxville, Tenn.
Leedy, H. A., Armour Research Foundation, Chicago, Ill.
Liming, C. A., Public Service Co. of Okla., Tulsa, Okla.
Machler, R. C., Leeds & Northrup, Philadelphia, Pa.
MacIsaac, W. A., N. S. Dept. of Mines, Glace Bay, N. S.
Malloch, C. D., Consumers Power Co., Jackson, Mich.
Mehtani, Y. S., Karelabagh Pumping Station, Allahabad, UP, India
Meyer, H. L., Consumers Public Power District, York, Nebr.
Mukherji, R. G., Govt. of Bengal, Dacca, Bengal, India
Murton, C. R., Commonwealth and Southern Corp., Birmingham, Ala.
Neblett, W. R., The Commonwealth & Southern Corp., Jackson, Mich.
Oldham, R. A., Federal Wire & Cable Co., Ltd., Guelph, Ont., Canada
Peebles, F. D., REA, Dept. of Agriculture, Washington, D. C.
Prier, A. J., General Elec. Co., Schenectady, N. Y.
Purandare, D. N., Western India Engg. Corp., Ltd., Bombay, India
Rankin, J. A., Belmont Radio Corp., Chicago, Ill.
Reinecke, E. P., Weltronic Company, Detroit, Mich.
Rodgers, E. J., Bureau of Ships, Navy Dept., Washington, D. C.
Saitzoff, A. M., MacDonald International, Inc., New York, N. Y.
Seshadri, B., % National Physical Laboratory, Teddington, England
Skinner, M. E. (Re-election), Buffalo Niagara Elec. Corp., Buffalo, N. Y.
Sommers, O. W., City Public Service Board, San Antonio, Tex.
Stoner, K. W., Corn Products Refining Co., Chicago, Ill.
Tormo, M. G., Merritt-Chapman & Scott, New York, N. Y.
Tour, G. I. (Re-election,) Tennessee Valley Authority, Knoxville, Tenn.
Trowbridge, C. A., Commercial Solvents Corp., Terre Haute, Ind.
Tse, P-Y,, Sin Chung Engineering Co., Shanghai, China
VanDkye, E. R., General Elec. Co., Atlanta, Ga.
Wadia, M. H., Capt. I. E. Royal Engineers, Coimbatore, South India
Wojcik, T. M., General Cable Corp., Rome, N. Y.
Wray, J. Q., Jr., Pennsylvania Water & Power Co., Baltimore, Md.
Wray, P. M., Wray Elec. Contracting, Inc., Cincinnati, Ohio
Wylie, R. R., Rumsey Elec. Co., Roanoke, Va.

56 to grade of Member

To Grade of Associate

United States and Canada

1. North Eastern

Ackerman, C. J., Lieut. Comdr., USNR, Office of the Resident Inspector of Naval Material, Syracuse, N. Y.
Armor, P. C., Brown University, Providence, R. I.
Blumenthal, I. S., General Elec. Co., Bridgeport, Conn.
Brennan, J. J., Ens., SC, USNR, Harvard Univ., Cambridge, Mass.
Brohl, E. M., Bendix Aviation Co., Norwood, Mass.
Bundy, R. C., Chance Vought Aircraft, Stratford, Conn.
Burns, R. C., SoundScriber Corp., New Haven, Conn.
Cole, B. T. (Re-election), Westinghouse Elec. Corp., Buffalo, N. Y.
Crook, C. W., Eastman Kodak Co., Rochester, N. Y.
Davidson, J. M., Electro Metallurgical Co., Niagara Falls, N. Y.
deWolf, G. L., General Elec. Co., Syracuse, N. Y.
DiNozzi, A. D., Raytheon Mfg. Co., Waltham, Mass.
Flint, G. E., The Derby Gas and Elec. Co., Derby, Conn.
Hutchings, F. F. (Re-election), Veterans Administration, Boston, Mass.
Johnson, A. H., Bell Aircraft Corp., Niagara Falls, N. Y.
Kellway, B. J., General Elec. Co., Schenectady, N. Y.
Korona, F. S., Buffalo Niagara Elec. Corp., Buffalo, N. Y.
Littleton, J. C., Corning Glass Works, Corning, N. Y.
Lowderback, C. J., 1092 Blue Hills Ave., Bloomfield, Conn.
Najarian, A. A., Royal Elec. Co., Inc., Pawtucket, R. I.
Neagle, N. M., General Elec. Co., Boston, Mass.
Rademaker, L. C., Jr., General Elec. Co., Schenectady, N. Y.
Russell, F. A., Chas. T. Main, Inc., Boston, Mass.
Saliba, A. C., General Elec. Co., Pittsfield, Mass.
Santa, M. M., Massachusetts Institute of Technology, Cambridge, Mass.
Sechrist, H. S., General Elec. Co., Schenectady, N. Y.
Simkins, W. C. G., Chas. T. Main, Inc., Boston, Mass.
Spehr, C. J., General Elec. Co., Schenectady, N. Y.
Stauffer, J. R., Philadelphia Elec. Co., Phila., Pa.
Sun, S-S., Massachusetts Institute of Technology, Cambridge, Mass.
Taylor, F. C., Narragansett Elec. Co., Providence, R. I.
Teich, P. J., General Elec. Co., Schenectady, N. Y.
Templeton, D. E., Electro Metallurgical Co., Niagara Falls, N. Y.
Weller, B. L., Remington Arms Co., Inc., Bridgeport, Conn.
White, G. M., General Elec. Co., Schenectady, N. Y.

2. Middle Eastern

Ader, C. M., Sr., Bethlehem Steel Co., Baltimore, Md.
Audi, J. M., Line Material Co., Zanesville, Ohio
Bellizzi, J. A., Lt., USNR, Naval Research Lab., Washington, D. C.
Blalock, V. (Mrs.), Day & Zimmermann, Inc., Philadelphia, Pa.
Brandt, D. P. (re-election), United Engineers & Constructors, Inc., Philadelphia, Pa.
Caplan, A. G., Duquesne Light Co., Pittsburgh, Pa.
Carlson, F. L., REA, Dept. of Agriculture, Washington, D. C.
Cavender, G. L., Pennsylvania Coal Products Co., Petrolia, Pa.
Crim, H. C., War Dept., Wright Field, Dayton, Ohio
Davis, E. T., Leeds & Northrup Co., Philadelphia, Pa.
Dietrich, W. K., Bethlehem Steel Co., Baltimore, Md.
Farkas, E. C., Reliance Elec. & Engg. Co., Cleveland, Ohio
Fibich, H. G., National Acme Co., Cleveland, Ohio
Garrett, G. S., Engineering Products Co., Charleston, W. Va.
Giordano, J. J., Westinghouse Elec. Corp., E. Pittsburgh, Pa.
Cross, W., Philadelphia Elec. Co., Philadelphia, Pa.
Gutierrez, G., Westinghouse Elec. Corp., E. Pittsburgh, Pa.
Hammel, R. T., Dist. of Columbia Govt., Washington, D. C.
Heller, J. H., U. S. Army Signal Corps, Lansford, Pa.
Hnyla, J., The Maryland Drydock Co., Baltimore, Md.
Irwin, C. B., Jr., Consolidated Gas Elec. Light & Power Co. of Baltimore, Baltimore, Md.
Jenner, W. C., Reliance Elec. & Engg. Co., Cleveland, Ohio
Kepner, J. W., Appalachian Elec. Power Co., Cabin Creek, W. Va.
Kimball, B. L., Sperry Gyroscope Co., Inc., Baltimore, Md.
Machuga, M. A., Aberdeen Proving Ground, Md.
Martin, J. W., Naval Ordnance Lab., Washington, D. C.
Merkel, H. E., U. S. Treasury Dept., Washington, D. C.
Perris, L., United Engineers & Constructors, Inc., Philadelphia, Pa.
Poe, H. V., Westinghouse Elec. Corp., E. Pittsburgh, Pa.
Pratt, J. M., Bull Dog Elec. Produts Co., Cincinnati, Ohio

Pryor, H., The Elec. Storage Battery Co., Washington, D. C.
Ratowsky, M., Bureau of Ships, Navy Dept., Washington, D. C.
Rau, A. W., Philadelphia Elec. Company, Philadelphia, Pa.
Reese, S. A., Philadelphia Elec. Co., Philadelphia, Pa.
Rhodes, A. W., Carbide & Carbon Chemicals Corp., South Charleston, W. Va.
Seifert, W. A., The Maryland Drydock Co., Baltimore, Md.
Shary, R. F., Westinghouse Elec. Corp., E. Pittsburgh, Pa.
Sheridan, C. J., Triplett Elect. Instrument Co., Bluffton, Ohio
Shook, W. R., Jr., Elec. Machinery Mfg. Co., Cleveland, Ohio
Skorup, G. E., R.C.A. Victor Division, Camden, N. J.
Slaton, J. H., Dayton-Acme Co., Cincinnati, Ohio
Smith, D. I., Wright Field, Dayton, Ohio
Stradling, L. J., Jr., Allis-Chalmers Mfg. Co., Philadelphia, Pa.
Swing, H. P., Day & Zimmermann, Inc., Philadelphia, Pa.
Toffolo, D. S., Naval Research Laboratory, Anacostia, D. C.
Travis, C. E., N. Y. Ship. Corp., Camden, N. J.
Urenka, J. J., Reliance Elec. & Engg. Co., Cleveland, Ohio
Wheeler, W. P., Westinghouse Elec. Corp., E. Pittsburgh, Pa.
Wolf, A. J., Westinghouse Elec. Corp., E. Pittsburgh, Pa.
Wolfinger, C. P., Philadelphia Elec. Co., Philadelphia, Pa.

3. NEW YORK CITY

Brenner, M., 12 W. 183rd St., New York, N. Y.
Browne, W. A., N. Y. Port of Embarkation, Brooklyn, N. Y.
Chognard, J. C., 235 E. 73rd St., New York, N. Y.
Claypool, L. C., Otis Elevator Co., New York, N. Y.
Haltenhoff, F. W., Jr., Gibbs & Cox, Inc., New York, N. Y.
Hillman, P. L., Press Wireless Mfg. Inc., Long Island City, N. Y.
Hughes, F. J., 2304 Sedgwick Avenue, N. Y., N. Y.
Ih, Y-H, Federal Telephone & Radio Corp., Newark, N. J.
Kopp, B. J., Public Service Elec. and Gas Company, Newark, N. J.
Karaus, F. J., Consolidated Edison Co. of N. Y., Inc., New York, N. Y.
Klinke, H. O., Air Reduction Co., Jersey City, N. J.
Lake, J. B., Jr., Westinghouse Elec. Intl. Co., New York, N. Y.
Long, F. V., Westinghouse Elec. Intl. Co., New York, N. Y.
Lozowick, J. H., Western Elec. Co., Kearny, N. J.
Mayo, S. E., Jr., Federal Telephone & Radio Corp., Newark, N. J.
Mrose, J. E., Federal Tel. & Radio Corp., New York, N. Y.
Ostberg, O. S., U. S. Army, APO, New York, N. Y.
Pratt, I. P., Jr., USS *Corregidor*, FPO, New York, N. Y.
Shmoys, J., Sperry Gyroscope Co., Garden City, L. I., N. Y.
Stanley, W. G., Federal Tel. & Radio Co., Newark, N. J.
Upor, W. B., Gibbs & Cox, Inc., New York, N. Y.
Vail, T. F. X., Federal Telephone & Radio Corp., Newark, N. J.
Walsh, J. M., 2035 Chatterton Avenue, New York, N. Y.
Wong, H., 1019 Longwood Ave., Bronx, N. Y.
Yockel, A. P., Mackay Radio and Telegraph Co., New York, N. Y.

4. SOUTHERN

Birdsong, T. S., Alabama Power Co., Birmingham, Ala.
Black, A. F., Jr., Virginia Elec. & Power Co., Richmond, Va.
Brownell, H. S. (re-election), Birmingham Electric Co., Birmingham, Ala.
Cross, F., Tennessee Eastman Corp., Oak Ridge, Tenn.
Gregg, R. C., Tennessee Valley Authority, Memphis, Tenn.
Jager, C. R., Alabama Power Co., Birmingham, Ala.
Hassinger, W. H., Jr., Alabama Power Co., Birmingham, Ala.
Johnston, J. A., Tri-County Elec. Cooperative, Inc., Leesburg, Va.
Killingsworth, H. M., Birmingham Elec. Co., Birmingham, Ala.
Long, O., Southern Bell Telephone & Telegraph Co., Birmingham, Ala.
Martin, L., Carbide & Carbon Chem. Corp., Oak Ridge, Tenn.
Moseley, S. T., General Elec. Co., Roanoke, Va.
Murray, R. L., Alabama Power Co., Birmingham, Ala.
Olschner, P. Q., 437 Fern Street, New Orleans, La.
Rudolph, O. B., Tennessee Eastman Corp., Oak Ridge, Tenn.
Smith, H. R., Alabama Power Company, Birmingham, Ala.
Starr, M. S., Line Material Co., Birmingham, Ala.
Wilder, D. B., Jr., St. Petersburg Peninsular Tel. Co., St. Petersburg, Fla.

5. GREAT LAKES

Anderson, J. G., University of Minnesota, Minneapolis, Minn.
Blomeyer, E. C., Automatic Elec. Co., Chicago, Ill.
Bozer, F., Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Cadorette, R. J., Electric Service Engineering Co., Chicago, Ill.
Cofer, T. N., Central Ill. Public Service Co., Springfield, Ill.
Czerny, J. P., Jr., A-C Spark Plug Div., GMC, Flint, Mich.
Danford, W. R., Jr., Indiana Service Corp., Fort Wayne, Ind.
Dilay, W., General Electric X-Ray Corp., Detroit, Mich.
Enoch, F. W., Jr., Monsanto Chemical Co., Monsanto, Ill.
Ertan, C., Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Fegley, V. S., Resistance Welder Corp., Bay City, Mich.
Gilbert, W. F., Michigan College of Mining & Technology, Houghton, Mich.
Grunwald, R., Illinois Bell Telephone Co., Chicago, Ill.
Hansen, J. D., Oflner Electronics Co., Chicago, Ill.
Hodsdon, A. E., Jr., Capt., U.S.A., Fort Snelling, Minn.
James, K. D., Harnischfeger Corp., Milwaukee, Wis.
Johnson, T. W., A-C Spark Plug Div., GMC, Flint, Mich.
Kantzer, J. M., Consumers Power Co., Jackson, Mich.
Kintner, G. W., Kingan & Co., Indianapolis, Ind.
Kirchner, F. B. (Re-election), General Motors Corp., Fisher Body Div., Detroit, Mich.
Knopf, W. C., Jr., Northwestern Univ., Evanston, Ill.
Levin, H. H., Automatic Elec. Co., Chicago, Ill.
Marhoun, G. W., Northern States Power Co., St. Paul, Minn.
McKillop, I. A., Commonwealth Edison Co., Chicago, Ill.
Mitchell, J. N., Wilson Laboratories, Chicago, Ill.
Morgan, T. O., Buick Motor Div., GMC, Flint, Mich.
Nelson, L. E., Hubbard & Co., Chicago, Ill.
Randall, D. T., 821 E. Johnson St., Madison, Wis.
Roberts, W., R.E.A., Sibley, Iowa
Rowe, D. M., Murray Corporation of America, Detroit, Mich.
Vizard, W. F., Cover Dual Signal, Chicago, Ill.
Vogen, L. M., Commonwealth Edison Co., Chicago, Ill.
Weber, J. P., Jr., Thordarson Elec. Mfg. Div., Chicago, Ill.
Welker, O. L., Barber-Colman Co., Rockford, Ill.
Weyand, R. P., Western Union Teleg. Co., Chicago, Ill.

6. NORTH CENTRAL

Fujimura, Y. J., 2415 Champa Street, Denver, Colo.
Greiner, J. A., Consumers Public Power District, Lincoln, Nebr.

7. SOUTH WEST

Cardwell, T. A., Jr., U. S. Engineers, Little Rock, Ark.
Caterson, H. L., Washington University, St. Louis, Mo.
Felling, W. E., U. S. Navy, Conway & Mason Rds., Clayton, Mo.
Gardner, K. G., General Elec. Co., Dallas, Tex.
Geery, P. W., Todd Houston Shipbuilding Corp., Houston, Tex.
Hartsfield, J. M., Houston Light and Power Company, Houston, Tex.
Johnston, A. B., Oklahoma Gas and Elec. Co., Ardmore, Okla.
Lewis, T. B., U. S. Engineer Office, Little Rock, Ark.
Moore, J. D., Humble Oil & Refining Co., Houston, Tex.
St. Pierre, W. W., Westinghouse Elec. Corp., St. Louis, Mo.
Shuffler, B. B., Freese & Nichols, Fort Worth, Tex.

8. PACIFIC

Anderson, R. W., Henger-Seltzer Co., Los Angeles, Calif.
Brannan, G. M., Southern Utility & Supply Co., Ajo, Ariz.
Burbeck, D. W., General Electric Co., Los Angeles, Calif.
Burchell, H. J. (Miss), General Elec. Co., Los Angeles, Calif.
Cottrell, B. P., Western Elec. Company, Phoenix, Ariz.
Delabar, V. J., U. S. Navy, San Francisco, Calif.
Duruturk, A., P. O. Box 1075, Palo Alto, Calif.
Frey, F. V., Municipal Lt. & Pr. Dept., City Hall, Pasadena, Calif.
Gerlach, A. A., Signal Corps, U. S. Army, Fresno, Calif.
Hamilton, A. E., Dept. of Water & Power, Boulder City, Nev.
Holland, C. H., General Elec. Co., Los Angeles, Calif.
Hook, W. M., Western Union Telegraph Co., Oakland, Calif.
Jones, L. R., Jr., Ensign, USNR, FPO, San Francisco, Calif.
Kenline, G. B., San Diego Gas & Elec., San Diego, Calif.
Montgomery, W. L., Office of Supervisor of Shipbuilding, USN, San Francisco, Calif.
Mulborn, A. W., Pacific Gas & Elec. Co., San Francisco, Calif.
Nafius, D. E., C. F. Braun & Co., Alhambra, Calif.
Osborn, F. C., Jr., USS *Higbee*, FPO, San Francisco, Calif.
Paul, W. H., Lt., Signal Corps, APO, San Francisco, Calif.
Reber, E. A., General Elec. Co., San Francisco, Calif.
Ross, N. C., Dow Chemical Co., Pittsburg, Calif.
Sakelaris, G. J., Ensign, USNR, USS *Rutland*, FPO, San Francisco, Calif.
Sterrett, D. H., USS *Wiseman*, FPO, San Francisco, Calif.
Sweetland, R. N., LOON Test Group, AATD, Port Hueneme, Calif.

9. NORTH WEST

Dunkle, S. L., % Communications Engineering, Hillfield, Utah
Johnson, H. E., Lt., USNR, Office of Port Director, Seattle, Wash.
Naden, E. T., Westinghouse Elec. Corp., Seattle, Wash.
Widrig, T. M., Trumbull Elec. Manufacturing Company, Seattle, Wash.

10. CANADA

Adamson, D. M., RCNVR, Darthmouth, N. S., Can.
Ball, W. B., University of Toronto, Toronto, Ont., Can.
Bath, D. T., University of Alberta, Edmonton, Alberta, Can.
Best, G. C., Turbo Research, Ltd., Leaside, Ont., Can.
Calderone, A. C., A. V. Roe Canada Ltd., Malton, Ont., Can.
Chinn, N. W., Dominion Rubber Co., Ltd., Montreal, Que., Can.
Cormick, H. L., University of Alberta, Edmonton, Alberta, Can.
Elliott, R. E., Amalgamated Elec. Corp., Toronto, Ont., Can.
Goudge, A. R., Canadian General Elec., Peterboro, Ont., Can.
Grosskurth, R. A., The Bell Telephone Co. of Canada, Toronto, Ont., Can.
Gusen, A., Hydro-Elec. Power Comm. of Ont., Toronto, Ont., Can.
Healey, A. J., Canadian Westinghouse Co., Ltd., Hamilton, Ont., Can.
Hicks, R. L., Canadian General Elec. Co., Toronto, Ont., Can.
Kravetz, A. J., National Research Council, Ottawa, Ont., Can.
Lam, M., National Research Council of Can., Ottawa, Can.
LeBus, G. H., Canadian Westinghouse Co. Ltd., Hamilton, Ont., Can.
Lytle, D. D., Canadian Westinghouse Co. Ltd., Hamilton, Ont., Can.
Newbury, E. W., Canadian Westinghouse Co. Ltd., Hamilton, Ont., Can.
Quentin, A. P., Canadian National Carbon Co., Ltd., Toronto, Ontario, Can.
Skillen, J. P., Canadian Westinghouse Co., Ltd., Hamilton, Ont., Can.
Slader, G. Y., McGill University, Montreal, Que., Can.
Smith, A. W., Automatic Elec. (Canada), Limited, Toronto, Ont., Can.
Stevinson, A. L., Canadian General Elec., Peterboro, Ont., Can.
Stothert, W. D., Dept. of Public Works, Calgary, Alberta, Can.
Taylor, R., Canadian Standards Assn., Toronto, Ont., Can.
Walker, W. M., British Columbia Elec. Railway Co., Vancouver, B. C., Can.
Wilmot, R. D., National Research Council, Ottawa, Ont., Can.
Winch, E. M. P., English Electric Co. of Canada, Ltd., Vancouver, B. C., Can.

Elsewhere

Barker, C. G., United River Plate Telephone Co., Buenos Aires, S. A.
Cabrera, F. H., The Mexican Light & Power Co., Ltd., Mexico, D. F., Mexico
del Campo y Gutierrez, A. M., Mexican Light and Power Co., Mexico D. F., Mexico
El Ansary, H., Electricity & Water Works, Mehalla, El-Kobra, Egypt
Gil, F., The Mexican Light and Power Co., Mexico D. F., Mexico
Giron, L. S., Mexican Light and Power Co., Mexico D. F., Mexico
Gronner, A., 2400 Durazno, Montevideo R. O. del Uruguay, S. A.
Meijling, J. (re-relection), Kooperativa Forbundet, Stockholm, Sweden
Ovalle, E., Empresa Nacional de Electricidad S. A., Santiago, Chile, S. A.
Palomo y P., O. R., Compania Colombiana de Electricidad, Barranquilla, Rep. de Colombia, S. A.
Rao, B. S., C.N.T. Institute, Vepery, Madras, India
Thorarensen, R., Icelandic State Electricity Control, Reykjavik, Iceland

Total to grade of Associate

United States and Canada, 232

Elsewhere, 12

OF CURRENT INTEREST

Eta Kappa Nu Honors Karapetoff

A dinner meeting in honor of Vladimir Karapetoff (F '12) emeritus professor of electrical engineering, Cornell University, Ithaca, N. Y., was held by Eta Kappa Nu, honorary electrical engineering fraternity in New York, N. Y., on January 21, 1946, on the occasion of his 70th birthday.

Professor Karapetoff, who incurred blindness in 1943, described the nature of the affliction and measures taken to overcome it in order to lend encouragement to others who may be afflicted similarly, particularly as a result of war injuries. He described how the first sign of impending trouble was a detached retina in one eye in May 1942 followed by the same impairment in the other eye in the following year, with subsequent complication by cataracts. Recent operations have brought a very limited ability to distinguish objects. However, by learning to read Braille including music, by writing with a typewriter using a continuous roll of paper, by the use of a Braille typewriter for preparing memoranda, and by the use of "talking books" or phonograph records prepared especially for the blind, he states that he is able to engage in activities limited only by time available.

Speaking on the subject "Dynamics of National Conflicts," Professor Karapetoff pointed out that the behavior of people and nations follows a pattern determined by natural laws and cannot be controlled by establishing a pattern of ideals no matter how desirable these may be. He likened the need for judicial powers in the United Nations Organization to that existing in other governments which are required to perform administrative, legislative, and judicial functions.

The meeting was sponsored by the New York alumni chapter of Eta Kappa Nu, which presented Professor Karapetoff with a record player and a set of records.

Construction Opportunities Booklet. The Committee on Opportunities for Veterans in the Construction Industry, an industry-wide committee upon which the AIEE is represented, announces publication of a booklet entitled "Opportunity Unlimited—A Guide for Veterans Interested in the Construction Industry." Addressed specifically to veterans, the booklet hopes to attract capable men to the industry on a long-range basis. It discusses the professions, skilled trades, apprentice training, and business opportunities. A number of copies are available at Institute headquarters and may be obtained by writing to the American Institute of Electrical Engineers, 33 West 39th Street, New York 18, N. Y.

Billion-Volt X Rays Produced

A new atom-smashing machine to which the name "sigmatron" has been applied was described recently by Doctor E. E. Charlton of the General Electric Company. In it an electron will be subjected to two processes of acceleration, first in a cyclotron and then in a betatron. The physical dimensions of the cyclotron and betatron are such that the former may be placed inside the latter to form the combined machine, which is said to produce billion-volt X rays.

Announcement of the artificial production of mesons, one of the chief constituents of cosmic rays, was made at a meeting of the American Physical Society in papers by Doctor G. C. Baldwin, A. J. Hartzler, and Doctor G. S. Klaiber, all of the General Electric Research Laboratory, and Doctor Marcel Schein of the University of Chicago. The meson is a particle considerably more massive than the electron, though lighter than the proton, and is produced in the atmosphere high above the earth's surface by cosmic radiation from outer space, lasting but a few millionths of a second on the average. Photographic evidence shows the production of mesons, as well as protons, electrons, positrons, and other particles, in the 100,000,000-volt betatron.

Long-Range Direction Finders. Long-range high-frequency direction finders which were able to locate underseas craft operating half way across the ocean were employed by the United States Navy during World War II. This fact was disclosed for the first time at a recent demonstration of the devices staged jointly by the United States Navy and the Federal Telephone and Radio Corporation, Newark, N. J., at the company's Great River, N. Y., experimental station. As the new direction finder relied upon the use of its radio by the enemy submarine to reveal its location, it was necessary to keep the development one of the most carefully guarded secrets of the war.

Engineering Vacancies. With a staff requirement of 3,200 to be met by July 1 of this year, the United States Department of the Interior Bureau of Reclamation, Denver, Colo., has vacancies for 2,250 engineers at salaries ranging from $2,320 to $5,180 per year, or engineering aides to be paid from $1,572 to $2,980 per year. Applicants will be judged on the basis of experience and training and will not be required to take written examinations although veterans are given preference in civil service appointments. Inquiries should be sent to the Bureau of Reclamation, Room 457, New Customhouse, Denver 2, Colo.

A Reading List for Electrical Engineers

The following well-chosen list of books of interest to electrical engineers has been compiled by the staff of the Engineering Societies Library. This selection was made from the collection added to the library during 1945. Some equally good books may have been omitted from the list but the desire of the compilers was for brevity rather than all-inclusiveness.

ENGINEERING CONTRACTS AND SPECIFICATIONS. By R. W. Abbott. John Wiley and Sons, Inc., New York, N. Y. 188 pages, $2.25. Some of the legal and business aspects of the engineering profession are presented in convenient reference form. This is written for practical engineers and contractors as well as college students.

NETWORK ANALYSIS AND FEEDBACK AMPLIFIER DESIGN. By H. W. Bode. D. Van Nostrand Company, Inc., New York, N. Y. 551 pages, $7.50. This is a treatise on general network theory with material on the design of nonfeedback as well as feedback amplifiers, particularly those of wideband type, and on miscellaneous transmission problems arising in wideband systems.

SIMPLE CALCULATION OF ELECTRICAL TRANSIENTS; AN ELEMENTARY TREATMENT OF TRANSIENT PROBLEMS IN LINEAR ELECTRICAL CIRCUITS. By G. W. Carter. Macmillan Company, New York, N. Y. 120 pages, $1.75. These calculations are based on Heaviside's operational method in linear electrical circuits with lumped elements. Engineering aspects are emphasized.

ELECTRONICS DICTIONARY. By N. M. Cooke and J. Markus. McGraw-Hill Book Company, Inc., New York, N. Y. 433 pages, $5. An illustrated glossary of more than 6,000 terms used in radio, television, industrial electronics, communications, facsimile and sound recording.

POWER SYSTEM STABILITY. Volume 1, Steady State Stability. By S. B. Crary. John Wiley and Sons, Inc., New York, N. Y. 291 pages, $4. Presents the fundamental theory underlying maintenance of continuous electric power under normal and abnormal operating conditions. Discusses applications of the theory of steady state stability. Volume II: Transient Stability (in preparation).

TRANSMISSION LINES. By F. C. DeWeese. McGraw-Hill Book Company, Inc., New York, N. Y. 297 pages, $3.50. This comprehensive work deals exclusively with the design, construction, and performance of lines for the transmission of electric power. Material is presented so as to be useful to beginners and advanced students.

ELECTRICAL COILS AND CONDUCTORS; THEIR ELECTRICAL CHARACTERISTICS AND THEORY. By H. B. Dwight. McGraw-Hill Book Company, Inc, New York, N. Y. 351 pages, $5. Most of the calculations presuppose a knowledge of the principles of the operation of electric apparatus and a working knowledge of integral calculus.

BASIC ELECTRICAL ENGINEERING; CIRCUITS, MACHINES, AND ELECTRONICS. By A. E. Fitzgerald. McGraw-Hill Book Company, Inc., New York, N. Y. 443 pages, $3.75. This is an elementary exposition of the electric-circuit theory requisite in the foundation of all electrical engineering students.

MECHANICAL AND ELECTRICAL EQUIPMENT FOR BUILDINGS. Second Edition. By C. M. Gay and C. de van Fawcett. John Wiley and Sons, Inc., New York, N. Y. 453 pages, $5. Covers basic theories and applications concerned with building equipment, including water supply, plumbing and drainage, heating and air conditioning, electric equipment, and acoustics.

ELECTROLYTIC CAPACITOR. By A. M. Georgiev. Murray Hill Books, Inc., New York, N. Y. 191 pages, $3. Describes the construction, manufacture, function, and testing of dry and wet electrolytic capacitors, explains the operating characteristics of the various types, and indicates their useful applications and limitations.

ENGINEERING PREVIEW; AN INTRODUCTION TO ENGINEERING INCLUDING THE NECESSARY REVIEW OF SCIENCE AND MATHEMATICS. By L. E. Grinter. Macmillan Company, New York, N. Y. 581 pages, $4.50. Treats the background science of engineering—mathematics, chemistry, physics, and technical drawing—to enable the reader to orient himself and determine whether engineering is the field he should choose.

CONTROLLERS FOR ELECTRIC MOTORS; A TREATISE ON THE MODERN INDUSTRIAL CONTROLLER WITH TYPICAL APPLICATIONS TO THE INDUSTRIES. By H. D. James and others. McGraw-Hill Book Company, Inc., New York, N. Y. 324 pages, $3.50. Describes the construction, performance, and operation of various types of commercial motor controls in general use. Protective devices are explained in detail, and a brief set of instructions for the installation and maintenance of the devices is included.

ELECTROMAGNETIC ENGINEERING. Volume I, Fundamentals. By R. W. P. King. McGraw-Hill Book Company, Inc., New York, N. Y. 580 pages, $6. This textbook is based on a war-training course. It avoids the use of higher mathematics.

TRANSMISSION LINES, ANTENNAS, AND WAVE GUIDES. By R. W. P. King, H. P. Minno, and A. H. Wing. McGraw-Hill Book Company, Inc., New York, N. Y. 347 pages, $3.50. The physical and mathematical background prerequisite to the systematic study of antennas, wave propagation, transmission circuits, including wave guides and microwave generators, is presented in this, the first of a proposed series of three volumes.

UHF RADIO SIMPLIFIED. By M. S. Kiver. D. Van Nostrand Company, New York, N. Y. 238 pages, $3.25. The concepts of ultrahigh-frequency radio are presented as logical outgrowths of the more familiar low-frequency equipment. Describes the important pieces of equipment: magnetron, oscillators, wave guides, cavity resonators, antennas, measuring instruments. Explains principles of reduction, transmission, and measuring of ultrahigh-frequency currents and waves.

MARINE ELECTRIC POWER. By Q. B. Newman. Simmons-Boardman Publishing Corporation, New York, N. Y. 244 pages, $2.50. This is an elementary textbook covering electrical theory, principles of electrical engineering, and use of electric equipment on ships.

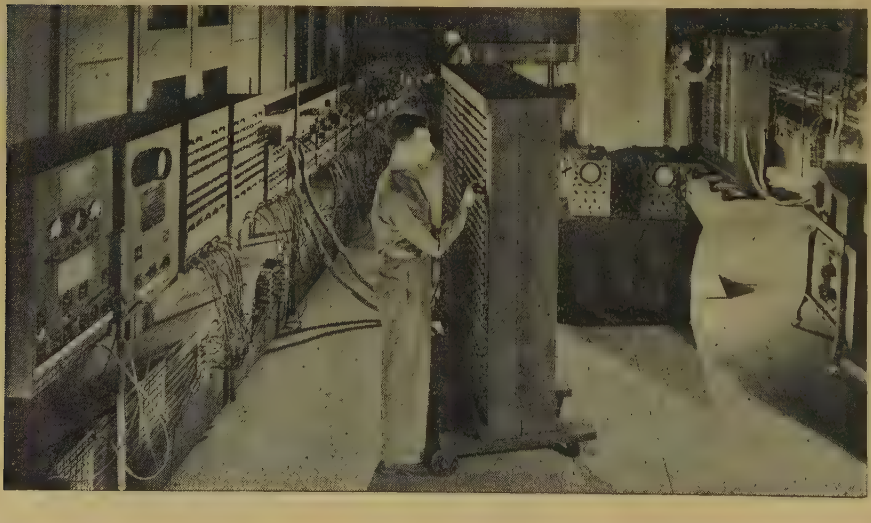
INDUSTRIAL ELECTRIC FURNACES AND APPLIANCES. Volume I. By V. Paschkis. Interscience Publishers, Inc., New York, N. Y. 232 pages, $4.90. Covers thermal, electric, and economic principles applying to all types of furnaces and appliances. Discusses arc furnaces and electrode-melting furnaces, with special attention to ferro-alloy furnaces. Emphasis is placed on the thermal aspects of furnace design and operation. A second volume will cover induction, capacitance, and resistance heating.

ELECTRONIC ENGINEERING MASTER INDEX, A SUBJECT INDEX TO ELECTRONIC ENGINEERING PERIODICALS. Edited by F. A. Petraglia. Electronic Research Publishing Company, New York, N. Y. 318 pages, $17.50. Contains approximately 15,000 entries nearly all of which refer to material published in English language technical magazines and society publications. No abstracts or annotations are included.

INTRODUCTION TO MICROWAVES. By S. Ramo. McGraw-Hill Book Company, Inc., New York, N. Y. 138 pages, $1.75. This is an elementary non-mathematical discussion of microwaves.

New Electronic Calculator

Officials who were responsible for the development of the "electronic numerical integrator and computor" designed and constructed by the Moore School of Electrical Engineering, University of Pennsylvania, Philadelphia, for the United States Army Ordnance Department are shown at its dedication. Containing nearly 18,000 vacuum tubes in its mechanism, the new calculator occupies a room 30 by 50 feet and weighs 30 tons. It is said to be the first all-electronic general purpose calculator and to compute 1,000 times faster than any similar machine previously built. Originally developed for the computation of firing and bombing tables for vital ordnance equipment, the device can find many peacetime applications in such fields as nuclear physics, aerodynamics, and scientific weather predictions. Left to right are J. P. Eckert, Jr., Moore School; Professor J. G. Brainerd (M '39) Moore School, and chairman of the AIEE committee on basic sciences; Sam Feltman, chief engineer for ballistics, United States Army Ordnance Department; Captain H. H. Goldstine, liaison officer; Doctor J. W. Mauchly, Moore School; Doctor Harold Pender (F '14) dean, Moore School; General G. M. Barnes, chief of the United States Army Ordnance Research and Development Service; and Colonel P. N. Gillon, chief of the research branch, United States Army Ordnance Research and Development Service



Message to Moon Proves Atmosphere Penetration

The principal significance of the radar-to-the-moon tests recently conducted by the United States Army Signal Corps, according to Major General Harry C. Ingles, Chief Signal Officer of the Army, is that they demonstrated for the first time that radio waves in the very high frequency band will penetrate completely the ionosphere, the celestial void, and whatever form of atmosphere that may surround the moon. Although the waves had to travel 238,000 miles to the moon the penetration was accomplished without distortion or refraction.

The radar set employed in the tests at the Evans Signal Laboratory, Belmar, N. J., was designed primarily for long-range detection of hostile aircraft but for transmission over so great a distance it was necessary to modify the oscillators and to add a second complete antenna unit. The set was operated on its standard frequency of 111 megacycles, a wave length of 300 centimeters, which lies in the very high frequency range.

REA Adds Electro-Agricultural Section. A new section of the Rural Electrification Administration's Technical Standards Division has been established to organize, promote, and co-ordinate programs in the development of new electro-agricultural equipment and the improvement of existing devices of benefit to the farmer according to an announcement made by Claude R. Wickard, administrator. The electro-agriculture section, as it will be known, will be concerned with the development of new electric equipment designed to meet farm needs and will work with colleges and other groups carrying on research programs. The information will be made available to manufacturers for commercial development and quantity production at lower costs. REA borrowers will be given information concerning new developments in electric equipment which will improve living conditions and increase farm profits.

INDUSTRY • • • • •

Gwilym A. Price
Westinghouse President

Gwilym A. Price, vice-president and member of the board of directors, has been elected president of the Westinghouse Electric Corporation, East Pittsburgh, Pa., to succeed George H. Bucher, who has resigned. Under a recent amendment of the corporation's bylaws, Mr. Price as president will be chief executive officer.

Mr. Price at the age of 50 is one of the United States' youngest directors of a large corporation. He was born in Canonsburg, Pa., in 1895 and is a graduate of the University of Pittsburgh Law School (1917). Prior to his election as an officer of the Westinghouse corporation in 1943, Mr. Price had been president of the Peoples-Pittsburgh Trust Company of Pittsburgh, Pa., an organization with which he had been associated since 1923.

Mr. Bucher will continue with the company as vice-chairman of the board of directors and as chairman of the Westinghouse Electric International Company.

Lighting Survey. A minimum of four million new luminaires or lighting fixtures for approximately 50,000 miles of automotive throughfare and 250,000 miles of residential streets at an estimated installed cost of 500 million dollars will be needed for new and replacement traffic safety lighting in the United States during the next ten years according to a recently completed survey of the country's lighting conditions made by Doctor A. F. Dickerson, manager of the lighting division, General Electric Company, Schenectady, N. Y. The survey emphasized the fact that improper illumination can be credited as the chief cause of increasing automobile accidents which claimed, during the period from December 7, 1941, to June 1, 1945, three casualties for every American war casualty.

Wire Stripping Method. After a year of production and demonstration, a method for removing insulation from fine electrical wires, developed by the Fairchild Camera and Instrument Corporation, Jamaica, N. Y., is said to have exceeded original expectations. Initially intended for application to wires covered with certain synthetics, it has enabled electrical manufacturers to strip all modern types of synthetic covered wires with no change in wire size or physical properties. In this method the ends of fine wire to be stripped first are dipped quickly in one chemical solution, then immediately in a final solution which acts as an accelerator, and then gently stroked to remove the insulation. The process is patented by the corporation which is licensing electrical manufacturers to use it.

Gas Turbine Progress. Successful operation at a gas temperature of 1,350 degrees Fahrenheit has been accomplished in tests on a gas turbine plant installed in the United States Naval Engineering Experiment Station, Annapolis, Md., it was announced recently. The 3,500-horsepower unit was designed by the Allis-Chalmers Manufacturing Company, Milwaukee, Wis., for eventual operation with hot gas at a temperature of 1,500 degrees Fahrenheit. It embodies cooling methods which permit the multistage turbines to operate safely at high inlet temperature by avoiding the undue weakening effect of the high temperature on the materials used for the rotating parts.

New Generating Station. Construction of a new generating station on the Arthur Kill at Sewaren, Woodbridge, N. J., is planned by the Public Service Electric and Gas Company for the autumn of 1946. The initial step in the project includes the installation of two 100,000-kw high-pressure high-efficiency generating units, with the necessary auxiliary apparatus, buildings, docks, electrical switching and transformer equipment, and connecting transmission lines, estimated to cost 23 million dollars.

Elastic Plastic. A new elastic plastic, "Marvinol" resin, has been developed by The Glenn L. Martin Company, Baltimore, Md., according to a recent announcement. The raw material will be manufactured by a new plant to be operated by the plastics and chemicals divisions of the company and will be sold only to converters and fabricators. Mixed with other substances, these polyvinyl resins can be used for a large variety of commercial products including multicolored wire insulation, woven fabrics, and industrial gloves.

"Electrical Living." Jobs for 600,000 persons and an annual business of more than four billion dollars for the next five years were forecast by B. W. Clark, vice-president in charge of sales of Westinghouse Electric Corporation, as a result of expanded application of electricity in homes. Speaking at a preview of new home products, Mr. Clark emphasized the need for adequate wiring in homes, and estimated that $150,000,000 per year for several years should be expended in rewiring existing homes. A color cartoon film produced by Walt Disney Studios has been made available to help inform the public of this need.

Newcomer in F-M Field. According to a recent announcement of the Federal Telephone and Radio Corporation, Newark, N. J., the company currently is building frequency modulated broadcast transmitting equipment for 170 installations, its initial venture into that field. The equipment will incorporate a new type of modulator-oscillator unit which is claimed to make possible a very low noise reception level.

Movie Presents Transportation Problem. An all-color sound motion picture, "Lifestream of the City," produced to illustrate the advantages of a well-planned efficient public transit system, has been made available by the General Electric Company, Schenectady, N. Y., to civic and business organizations, schools, colleges, and transit and power companies. The film attempts to prove that modern public transit vehicles, by using existing street space more efficiently, will solve the traffic congestion problem caused by the increasing use of private automobiles. Information about the film, which can be used on sound-equipped 16-millimeter projectors only, may be obtained from the company's visual instruction section, Schenectady, N. Y., or by inquiry at any local office.

"Standardized" Steam Turbines. In accordance with "Preferred Standards for Large 3,600-Rpm Three-Phase 60-Cycle Condensing Steam Turbine Generators" prepared by the joint committee on steam turbine generators of the AIEE and the American Society of Mechanical Engineers (*EE, May '45, p 180*), the first "standardized" steam turbine built for electric power generation is in production at the South Philadelphia, Pa., plant of the Westinghouse Electric Corporation, L. E. Osborne, vice-president, announced recently. The unit, a 30,000-kw machine, initiates a program of standardization which, it is expected, not only will speed up production but will facilitate repairs and servicing.

Hermetically Sealed Rectifier. A selenium rectifier which can be submerged in boiling water or packed in ice and still function at an efficiency equal to that obtained under normal operating conditions has been announced by the Westinghouse Electric Corporation, East Pittsburgh, Pa. The rectifier was designed for wartime use to withstand the extreme temperatures experienced on the various battlefronts. It is said also to resist salt spray, insects, fungi, and humidity.

RESEARCH • • • • •

Aeronautical Laboratory for Cornell. The combined gifts to Cornell University, Ithaca, N. Y., of the Curtiss-Wright Corporation's airplane division research laboratory, Buffalo, N. Y., and $675,000 in working capital from seven aircraft companies provide the university with a laboratory in which industrial research can be carried on simultaneously with the professional training of aeronautical engineering students according to Doctor C. C. Furnas, the laboratory's director. The staff of instruction will be selected both from the laboratory and from the college of engineering at the university and students will divide their time between the Ithaca campus and Buffalo.

MIT Acoustics Laboratory. Establishment of an acoustics laboratory, a new interdepartmental facility in a branch of science which produced important developments during World War II, was announced recently by Doctor Karl T. Compton (F '31) president, Massachusetts Institute of Technology, Cambridge. One of the primary objectives of the new laboratory is to provide fundamental professional training in a field in which there is now a serious shortage of competent engineers and scientists. It is to be operated under the joint direction of the institute's departments of electrical engineering and physics and the school of architecture and planning with Doctor Richard H. Bolt as director.

OTHER SOCIETIES •

Award Fund. The American Association for the Advancement of Science, Washington, D. C., has announced the establishment of the George Westinghouse Science Writing Award Fund to give recognition to newspaper writers and newspapers contributing most to effect a better popular understanding of the achievements of science and technology. The fund, which will be administered by the association, is supported by the Westinghouse Electric Corporation in commemoration of the 100th anniversary of the birth of George Westinghouse. In addition to the cash award and the citation, special citations in recognition to distinguished service in science journalism may be awarded. The first annual awards, for the year 1946, will be made at the winter meeting of the association in December 1946.

Ophthalmology Publication. "Industrial Aspects of Ophthalmology," proceedings of a 1944 seminar conducted by the National Society for the Prevention of Blindness, 1790 Broadway, New York 19, N. Y., is now available from that society. The price is one dollar. The contents of the 150-page publication include "Survey of Eye Conditions in Industry," "Industrial First Aid—Eye Injuries," and "Improving the Visibility of Industrial Tasks."

Welding Inspection Handbook. The "Inspection Handbook for Manual Metal Arc Welding" published by the American Welding Society now is available. It covers the requirements and duties of a welding inspector, methods of testing welds, and contains a description of weld inspection by visual, magnetic-particle, and radiographic methods. Copies may be obtained from the American Welding Society, 33 West 39th Street, New York 18, N. Y., at $1.50 each.

Future Meetings of Other Societies

American Association for the Advancement of Science. March 27–29, 1946, St. Louis, Mo.

American Chemical Society. National Chemical Exposition. September 10–14, 1946, Chicago, Ill.

American Society for Testing Materials. Forty-ninth annual meeting. June 24–28, 1946, Buffalo, N. Y.

American Society of Mechanical Engineers. Spring meeting. April 1–3, 1946, Chattanooga, Tenn.

American Society of Tool Engineers. Exposition. April 8–12, 1946, Cleveland, Ohio.

Electrochemical Society. Spring meeting. April 10–13, 1946, Birmingham, Ala.

Great Lakes Power Club. Spring meeting. May 24, 1946, Chicago, Ill.

Illuminating Engineering Society. National convention. September 18–21, 1946, Quebec, Quebec, Canada.

Instrument Society of America. Exhibit and conference. September 16–20, 1946, Pittsburgh, Pa.

Midwest Power Conference. Annual meeting. April 3–5, 1946, Chicago, Ill.

National Association of Corrosion Engineers. Annual meeting and convention. May 7–9, 1946, Kansas City, Mo.

National Electrical Manufacturers Association. First International Lighting Exposition. April 25–30, 1946, Chicago, Ill.

Pennsylvania Electric Association. Spring meeting. May 28–29, 1946, Harrisburg, Pa.

Radio Manufacturers Association. Trade show. May 13–16, 1946. Chicago, Ill.

Society of Plastics Industry. First national plastics exposition. April 22–27, 1946, New York, N. Y.

LETTERS TO THE EDITOR

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinions dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers. Publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

Behavior of a Freely Pivoted Disk

To the Editor:

As the gyrostat long since has come within the ambit of the electrical engineer's professional interests, a letter on the subject seems not out of place. Does not the fascination of the running gyrostat's behavior cause us to overlook some quite remarkable characteristics of the stationary pivoted disk, characteristics which on the one hand illustrate second-order torque terms of the running gyrostat; and on the other hand, in spite of the minuteness of these terms, are susceptible of the easiest possible practical demonstration. Not only are these of immediate interest as unexpected effects, but an appreciation of them fortifies our subconscious critical faculty against erroneous though plausible arguments which have appeared[1] fairly recently under even the most distinguished authorship. For instance, we may need to define our meaning of angular velocity of the gyrostat's disk about its spin axis when that axis simultaneously is changing its inclination to the vertical and swinging about the vertical (precession), and we may be seduced by its simplicity to adopt for this definition the rate of change of angular interval between a marked radius on the disk and that particular radial line which is horizontal at the moment under consideration. This quantity ϕ certainly defines a real angular velocity, but we shall be begging the question if we tacitly assume that it is the actual angular velocity of spin such as would be ascertained by fundamental kinematical examination and which, as is known, remains constant in the absence of external torque about the spin axis. It is a well-known dynamical fact[2] that, for a disk pivoted on a principal axis passing through its center of mass and having the

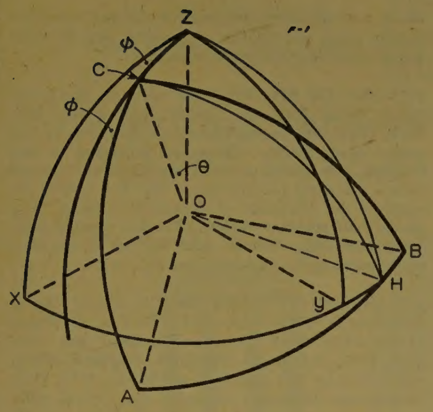


Figure 1. Diagram of Euler's moving axes *ABC* fixed in the gyrostat disk and related by the co-ordinates $\theta\phi\psi$ to the axes *XYZ* fixed in space

The line OH has been added at right angles both to OC the spin axis and to OZ the vertical, therefore representing that radius of the disk which is horizontal. HB thus becomes the angular interval between the horizontal radius and the marked one, and will be seen to be equal to Euler's ϕ

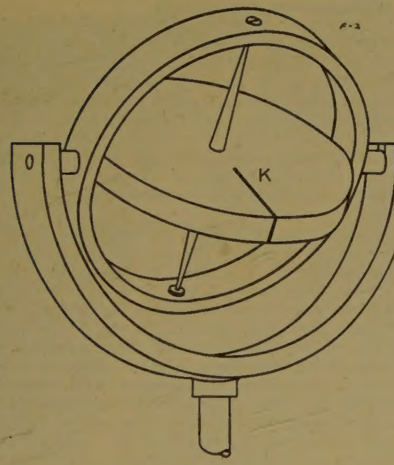


Figure 2. Demonstration-type gyrostat

other two principal moments of inertia equal the one to the other about axes through that center, the true angular velocity about the axis of pivoting—which we here call ω_3—is unaffected by any movement given to the spin axis, for instance via gimbal rings, and is subordinate only to external couple such as pivot friction and kindred. But this property of constancy does not pertain to ϕ; indeed ϕ will be found to correspond to one of the co-ordinates of the disk used in Euler's analytical method wherein moving rectangular axes fixed in the disk are referred by the co-ordinates $\theta\phi\psi$ to a similar set fixed in space, and the true velocity of spin ω_3 is given by $\phi+\dot{\psi}\cos\theta$ (see Figure 1).

In the case of the running gyrostat, the term ψ is so small compared with $\dot{\phi}$ that we could not expect to find any simple experimental differentiation between ω_3 and ϕ; but the known constancy of angular velocity is true irrespective of its numerical value, and therefore also when this value is zero. In those circumstances $\dot{\psi}$ becomes the major part of the quantity examined, hence the beauty of a test on the pivoted disk without spin. Let us then take an ordinary gyrostat as depicted in Figure 2 and clamp the trunnions so that the spin axis makes an angle of about 30 degrees with the vertical. Let the disk be at rest and free in its pivots and let a chalk mark *K* be made on the top surface of the disk along the lowest radius. Now let us turn the yoke upon its vertical pivot slowly enough for the effects to be watched. The chalk mark does not stay at the bottom, nor is pivot friction responsible for the movement relative to gimbal ring since it is in the reverse direction. By continuing the turning of the yoke the chalk mark may be brought to the top, and on around to the bottom again, and so on; yet it may be asserted confidently that ω_3, the velocity of the disk about its spin axis, has been zero all the time except to the extent that slight pivot friction has been at play and has caused turning of the disk in the direction opposite to that believed to have been observed. We thus shall have seen that since ϕ started with zero value, and subsequently assumed various values, it is not a quantity which can be used as a measure of spin velocity. We still are left with the apparent paradox of the test appearances on the one hand, and the knowledge that the disk cannot have turned upon its axis in the observed direction. The explanation is simple*; but it may suffice here merely to make the bold assertions that, in spite of the trunnion axis remaining horizontal all the time, it was that axis, and not the disk, which turned about the spin axis causing a relative movement of chalk mark and trunnion axis, and the chalk mark moved from a low to a high position on the disk, and changed in its North–South azimuth, by tilting of the disk about a succession of diameters, and not by rotation of the disk on its spin axis.

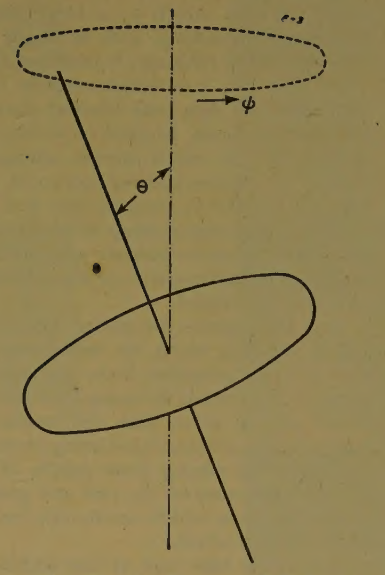


Figure 3. Simple diagram defining the co-ordinates $\theta\psi$

Of other characteristic properties of the freely pivoted disk one only will be referred to, namely the simulation of negative centrifugal force, an effect again affording instant check upon analytical results. It arises in this way. Taking again the gyrostat of Figure 2 with the disk at rest, but this time with the trunnions free, let us give the yoke a slight spin in either direction about its vertical pivot and watch the behavior of the inner gimbal ring. It is clear that, were the disk jammed in its pivots, the inner ring would turn on its trunnions to bring the disk axis toward the vertical, this being the normal result of centrifugal force on elements of the disk. The actual result, with pivots free, is the reverse of this. Two questions present themselves here. May the pivot friction cause a sufficient spin of the disk for the resulting large gyrostatic effect to cause the observed turning toward the horizontal? The answer is that such spin as may be produced will cause a reverse tendency not a helping one. Can the centrifugal force upon the inner gimbal ring itself, which is certainly in the right direction, be responsible? The gimbal ring is usually relatively light, but this query only can be answered positively by countering the couple produced by the said centrifugal force. For his personal satisfaction the writer modified a two-ring torpedo gyrostat by attaching a structure to the inner ring whereby weights could be located suitably outside the outer gimbal to counter the couple of the centrifugal forces upon the inner one. The test result was unchanged. So much for qualitative demonstration. For quantitative verification recourse must be had to calculation, namely a determination of that part of the torque about the trunnion axis which is required to counter the inertia couple produced by the disk. The result for the case of jammed pivots is found easily by simple procedure. For the case of the freely pivoted disk we may choose to remain on unassailable ground using Euler's equations and co-ordinates and resolving the couples and then substituting in the final result zero value for the angular velocity of disk spin. The calculation however can be made quite soundly using these same co-ordinates (see Figure 3) and treating the components of angular momentum as vectors.[3] The results will be found to be

for the freely pivoted disk

$$A\ddot{\theta}-{}^{1}/_{2}A\dot{\psi}^{2}\sin 2\theta$$

for jammed pivots

$$A\ddot{\theta}+{}^{1}/_{2}(C-A)\dot{\psi}^{2}\sin 2\theta$$

where *A*, *A*, *C*, represent the three principal moments of inertia at the disk's centroid. If now the disk be reasonably thin for its diameter, the larger moment of inertia *C* will be substantially equal to 2*A* and therefore the said trunnion torque required to hold θ constant, with given values of θ and ψ, will be the same for the two conditions of pivots except only for sign. We thus have complete simulation of negative centrifugal force. We note that with free pivots, since ψ^2 is essentially positive, $\ddot{\theta}$ is necessarily of the same sign as sin 2θ if the trunnions are free, an immediate check upon the sign of our second-order torque term for the running gyrostat.

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* The two assertions will be acceptable to the reader if he will consider the result on the ring and the disk of giving a small displacement $\delta\psi$ to the yoke about its vertical axis, which is equivalent to $(-\delta\psi\sin\theta)$ about a line momentarily coinciding with the lowest disk radius plus $(\delta\psi\cos\theta)$ about the spin axis. He will note that the second component can have no effect upon the disk in the absence of pivot friction.

REFERENCES

1. *Proceedings*, Institution of Mechanical Engineers, London, England, volume 151, pages 232–3.

2. Dynamics of a System of Rigid Bodies, **E. J. Routh.** Macmillan and Company Limited, 1891, volume 1, page 215.

3. A Treatise on Gyrostatics and Rotational Motion, **Andrew Gray.** Macmillan and Company Limited, 1918, pages 51–6.

4. 1915 Kelvin Lecture, **Andrew Gray.** *Journal* Institution of Electrical Engineers, London, England, volume 53, pages 293–4.

A. B. FIELD (F '13)

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Liberal Education for Engineers

To the Editor:

The need of liberal education for engineers becomes more and more evident. Every new scientific discovery is hailed as a boon to mankind. However, advancement, if indeed any, toward producing more human happiness as a result of new scientific discoveries, has been very slow. History proves instead that all scientific discoveries are turned towards destructive rather than creative ends. This is, of course, not the scientist's purpose, but is due to a combination of lack of interest and wrong thinking on the part of the average individual including the scientist and engineer.

Engineers as men of science are men of logic and reason along those lines, and therefore, have a very good start toward becoming our most logical thinkers along social lines providing they avail themselves of the necessary information and thus have their interest aroused.

Due to economic conditions the engineer after leaving college devotes most of his time to the business of making a living. He, therefore, strives constantly to improve his technique in the engineering service rendered with a view toward greater remuneration and in doing this tends to lose sight of the importance he might play in the shaping of a better world, in which his labors would be turned toward maximum usefulness for humanity.

In order to improve the afore-mentioned condition and make the engineer more social-minded and thus a better world citizen, it seems that much greater emphasis must be placed on liberal education in our engineering colleges. Languages, literature, and philosophy are essential, and an objective study of the most controversial subjects, which to a large degree influence our thinking, such as world history, and world religions, is most essential.

The last two mentioned subjects have throughout the ages been handed down in their various forms, as right or wrong, depending on the vested interest advancing them in the various parts of the world, and therefore in order to advance clear and free thinking these subjects must be studied objectively in the same manner as a problem in physics or mathematics or the subject of mythology is studied.

Thus the engineer by taking the lead in logical thinking along the social lines as well as the engineering lines, and usually being in the position of having little specific vested interest other than the welfare of humanity as a whole, would bring about an understanding among more people of the underlying reasons for the past and present world conditions which continually lead to wars and destruction.

In order to take care of this additional liberal education in engineering colleges an additional year or two may have to be added to the present four-year term.

Eventual results to be expected are: greatly corrected thinking due to objective study of history, religion and philosophy resulting in world federation with abolition of wars, establishment of free trade, freedom of religion, tending toward higher and yet higher plane of clear and free thinking, the steady advance of science for the benefit of mankind and not for destruction.

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NEW BOOKS • • •

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

ENGINEERING ALLOYS, NAMES, PROPERTIES, USES. 2nd edition. By N. E. Woldman and R. J. Metzler. American Society for Metals, Cleveland, Ohio, 1945. 832 pages, tables, $9^1/_4$ by 6 inches, cloth, $10. Section I of this compilation is an alphabetical list of alloys with corresponding serial numbers. In the more than 400 pages of Section II are given the alloy trade name, composition, properties, uses, and key numbers designating the manufacturers. The alloys are here listed by serial number. Section III is an alphabetical subject index of special characteristics and typical uses. Section IV is a directory of manufacturers with their addresses and a summary of the alloys produced by each.

TABLES OF ASSOCIATED LEGENDRE FUNCTIONS. By the Mathematical Tables Project, under the sponsorship of the National Bureau of Standards. Columbia University Press, New York, 1945. Pages xlvi + 306, tables, 11 by $7^1/_4$ inches, cloth, $5. The present volume of a series of mathematical tables was produced to meet needs for a table of Legendre functions to about six significant figures at intervals of 0.1.

TECHNOLOGY OF PLASTICS AND RESINS. By J. P. Mason and J. F. Manning. D. Van Nostrand Company, New York, 1945. 493 pages, illustrated, diagrams, charts, tables, $9^1/_4$ by 6 inches, cloth, $6.50. The first section discusses the resinous and plastic states. In the second section, the methods of preparation and the properties and uses of the more important resins and plastics are covered, and the third section describes fabrication techniques.

THEORY OF SOUND. 2nd edition. By J. W. Strutt, Baron Rayleigh. Dover Publications, New York, 1945. 984 pages, diagrams, tables, $8^1/_2$ by $5^1/_2$ inches, cloth, $4.95. Originally published in two volumes, this treatise is now re-issued in one volume with a historical introduction. The first half is devoted to the vibrations of dynamical systems. The second half covers a variety of topics ranging from aerial vibrations, through fluid friction, to the facts and theories of the process of hearing.

TRANSMISSION LINES, DESIGN, CONSTRUCTION AND PERFORMANCE. By F. C. DeWeese. McGraw-Hill Book Company, London and New York, 1945. 297 pages, illustrated, diagrams, charts, tables, $8^1/_2$ by $5^1/_4$ inches, cloth, $3.50. With clear explanation, illustrative examples, and typical problems, this book presents both the fundamental and the more involved aspects of electric power transmission engineering. It provides data and material applicable not only to transmission line problems but also to other problems of a similar nature.

WAVEFORM ANALYSIS, A GUIDE TO THE INTERPRETATION OF PERIODIC WAVES, INCLUDING VIBRATION RECORDS. By R. G. Manley. John Wiley & Sons, New York; Chapman & Hall, London, 1945. 275 pages, illustrated, diagrams, charts, tables, $8^3/_4$ by $5^1/_2$ inches, cloth, $4. Although this book is in the nature of a guide rather than a comprehensive treatise, it includes sufficient basic theory and methods of analysis for the student to acquire a groundwork of knowledge concerning the properties of complex waveforms. The envelope method of analysis is presented in detail, with subsequent discussion of other methods

WILLIS RODNEY WHITNEY, PIONEER OF INDUSTRIAL RESEARCH. By J. T. Broderick. Foreword by K. T. Compton. Fort Orange Press, Albany, N. Y., 1945. 324 pages, illustrated, $8^1/_2$ by $5^1/_2$ inches, cloth, $3. This biography covers Willis R. Whitney's life up to and during the time he was director of the research laboratory of the General Electric Company. Much of the book is in Mr. Whitney's own words from addresses or letters.

URANIUM and ATOMIC POWER. By J. De Ment and H. C. Dake. Chemical Publishing Company, Brooklyn, N. Y., 1945. 343 pages, illustrated, diagrams, charts, tables, 9 by $5^1/_2$ inches, cloth, $4. A brief discussion of the background and possibilities of atomic power is followed by chapters on the constitution of uranium minerals and prospecting methods. The physics and chemistry of uranium as well as the methods used in its detection and determination are included. A large bibliography of original sources of information and a number of tables of useful data are appended.

PAMPHLETS • • •

The following recently issued pamphlets may be of interest to readers of "Electrical Engineering." All inquiries should be addressed to the issuers.

Material-Handling Handbook. Electric Industrial Truck Association, 209 South Wells Street, Chicago 4, Ill., 56 pages.

Radar on Wings. Philco Corporation, Philadelphia, Pa., December 1945, 32 pages.

An Examination of the Department of State's Proposals for Expansion of World Trade and Employment. The American Tariff League, 19 West 44th Street, New York 18, N. Y., 26 pages.

Methods of Testing and Protecting Eyesight in Industry. Prepared by the Industrial Health Section. Policyholders Service Bureau, Metropolitan Life Insurance Company, 1 Madison Avenue, New York 10, N. Y.

FTR Nomographs for Engineers (second set of a series). Federal Telephone and Radio Corporation, Newark 1, N. J., 16 nomographs.